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CONTENTS

NOTES ON THE SPIDERS OF THE SOUTHEASTERN UNITED STATES WITH DESCRIPTIONS OF NEW SPECIES. *Sherman C. Bishop and C. R. Crosby*..... 165

NOTES ON THE GENUS APHANOMYCES, WITH A DESCRIPTION OF A NEW SEMIPARASITIC SPECIES. *J. N. Couch*..... 213

PLANKTON COLLECTIONS IN LAKE JAMES, NORTH CAROLINA, COPEPODS AND CLADOCERA. *R. E. Coker*..... 228

THE MODERN ELECTROMETER. *Otto Stuhlman, Jr*..... 259

NOTES ON WOODY PLANTS. *W. W. Ashe*..... 267

FURTHER NOTES ON HYDNUMS. *W. C. Coker*..... 270

TUCKAHOE ON MAIZE. *Frederick A. Wolf*..... 288

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NOTES ON THE SPIDERS OF THE SOUTHEASTERN UNITED STATES WITH DESCRIPTIONS OF NEW SPECIES

By Sherman C. Bishop and C. R. Crosby

Plates 20–25

Introduction

The spider fauna of the southeastern United States is of the greatest interest for it was here that Nicholas M. Hentz, the father of the American arachnology, spent many of the most productive years of his life, and the type localities of a large proportion of the species described by him are in the states of North Carolina, South Carolina, Alabama and Georgia. It was also in Georgia, at a much earlier day, that John Thomas Abbot spent several years in collecting and painting many of the larger spiders. His specimens and drawings were later used by Baron Charles Athan Walckenaer in describing a large number of species.

It has been impossible in many cases to recognize the species described by these early authors and the problems can be settled only when the spider fauna has been more carefully studied and the species fully described and accurately figured. It is greatly to be hoped that zoölogists living in this region will take a greater interest in this neglected field.

This paper is based on a study of specimens collected in October, 1923, in the Blue Ridge Mountains of North Carolina and in the summer of 1912 in the Okefinokee swamp in southeastern Georgia. We have also been fortunate in having for study an extensive series of specimens

collected by the late Herbert H. Smith and loaned by the Alabama State Museum.

With the exception of the first six figures, which were made by Miss Anna C. Stryke, the drawings for this report have been prepared by Mr. Walter J. Schoonmaker, of the New York State Museum staff.

Sub-order ARANEAE THERAPHOSAE

Family AVICULARIIDAE

Genus **MYRMEKIAPHILA** Atkinson

We have followed Atkinson's spelling of the genus.
Type *Mygale fluviatilis* Hentz (*foliata* Atkinson).

Myrmekiaphila fluviatilis Hentz. Figs. 1–6.

There does not seem to be any doubt that *foliata* Atkinson is the same as *fluviatilis* Hentz. In 1886 Atkinson (Ent. Am. **2**: 132) described *foliata* as a new species from five female specimens. The dates and circumstances connected with the finding of these five specimens are described on page 113 of the same Journal. Of these specimens two are in the Cornell University collection. They are partly grown females. One of these is the first one collected, on March 13, 1886, and the other is without date. Atkinson apparently drew his description from mature specimens. We have a full grown female from Knoxville, Tenn., which fits his description fairly well and a male from the same locality which evidently belongs to this species. There is another male without locality in the Cornell collection which agrees with it. We also have three males from Alabama. Atkinson on page 115 speaks of a sixth specimen as follows: "Another specimen was found, about which, unfortunately, I have no record nor recollection, except that it was collected sometime during the spring. This, though I have not given it careful examination, I believe to belong to the same species. I left it in the possession of Dr. George Marx, at Washington."

In 1891 E. Simon (Actes Soc. Linn. Bordeaux **44**: 316) described a new species of *Myrmeciophila, atkinsoni,* from a female from Occoquan Falls, Va., sent him by Geo. Marx. In this description he compares the species with *M. foliata.* Under the latter he mentions having received a specimen from Dr. Marx, from Chapel Hill, N. C. This specimen is without doubt the one Professor Atkinson left with Marx without carefully determining it. Mr. Louis Fage of the Museum

National d'Histoire Naturelle of France, reports that he is unable to find the type specimen of *M. atkinsoni* in Simon's collection at Paris.

From an examination of Atkinson's specimens in the Cornell University collection we note the following differences when compared with his description: The anterior eyes are separated from each other by one-third the diameter. The posterior lateral eyes are a little smaller than the anterior median. The posterior median eyes are separated from the posterior lateral by one-half the diameter of a median.

Male. Length, 14 mm.; length of cephalothorax 7.5 mm., width 6 mm. Cephalothorax bright reddish brown, duller behind the dorsal furrow, radiating lines darker. Between the eyes and the median groove there is a straight median line and a pair of sinuous dark lines bearing a few setae and enclosing a lighter colored area. Thorax distinctly margined posteriorly and armed on the edge with a few stout setae. Eye area black; a group of stout setae on clypeus in front of the anterior median eyes and a group of three between the posterior eyes.

Anterior eyes in a procurved line, the lateral about two times the diameter of the median; the median separated from each other by three-fifths the diameter and from the lateral by four-fifths the diameter of the median. Posterior eyes in a slightly recurved line, about equal in size and only very slightly larger than the anterior median; the median separated from each other by $2\frac{2}{5}$ the diameter and from the lateral by a little less than the diameter (fig. 1). Sternum, coxae and trochanters lighter than dorsum.

Legs reddish brown above and lighter beneath. Tibia of first leg slightly swollen, armed in front towards the tip with large groups of heavy, blunt, black spines, and on the posterior side with a row of these spines thicker towards the tip. Metatarsus compressed, notched ventrally and widened and angulate distally below, armed with strong spines (fig. 2). Chelicerae reddish brown, armed on the front with numerous stout setae, shorter and stronger along the inner margin towards tip. The front surface has two smooth areas as shown in figure 3. The rake consists of a group of heavy blunt spines. Furrow of the chelicera armed on the inner side with seven stout teeth.

Palpus colored like the legs; femur slender, cylindrical; patella short. Tibia nearly as long as femur, swollen, and dilated into a triangular process on the outer distal angle. Tarsus very short, truncate and emarginate at tip. Bulb short and thick at base, the basal division represented by a highly chitinized lunate sclerite. Embolus short, curved and minutely saw-toothed on the outside of the curve (figs. 4–6).

Redescribed from 1 male. Knoxville, Tenn.

Alabama: Silas, Feb. 19, 1912, 1♂, Smith, coll.; University, May, 1♀; McGus Station, Montgomery Co., Oct. 24, 1915, 1♂, Smith, coll.

North Carolina: Chapel Hill, March 13, 1886, 1♀ immature; April (?) 1886, 1♀ immature, Atkinson, coll.

Tennessee: Knoxville, Mar. 4, 1920, 1♂ and 1♀, Cartwright, coll.

Texas: Austin, April 21, 1913, 3♀, Hartman, coll.

Myrmekiaphila comstocki n. sp. Figs. 7 and 8

Male. Length, 12 mm. Cephalothorax dusky yellowish brown, lighter on the head, radiating lines darker, distinctly impressed. Eye area black, a group of stout setae on clypeus in front of the anterior median eyes, and one spine between the posterior median eyes and a transverse row of four spines behind these eyes.

Anterior eyes in a procurved line, the median one-half the diameter of the lateral, separated from each other and from the lateral by a little less than the diameter of the median. Posterior eyes in a slightly recurved line, equal in size, the median separated from each other by twice the diameter and from the lateral by three-fourths as much. Underside of cephalothorax lighter than above. Legs reddish brown above and lighter beneath. Tibia of first leg not swollen as in *fluviatilis;* armed on the side with numerous heavy long black spines, thicker and stronger on the posterior side near the tip. Metatarsus of the same general form as in *fluviatilis* but more slender, less deeply notched below and not so strongly dilated distally. Chelicerae armed above much as in *fluviatilis* but the smooth areas are larger so that the rows of spined areas do not reach the base. The rake less strongly developed than in *fluviatilis*. Furrow of the chelicera armed on the inner side with 7 or 8 stout teeth and on the outer side with a row of very small teeth near the tip of the claw.

Palpus colored like the legs, darker distally. Femur slender, patella short. Tibia swollen, not quite so long as the femur; the triangular process on the outer distal angle about the same as in *fluviatilis*, but the tip does not project into such an acute point, more nearly square (fig. 7). Tarsus similar to *fluviatilis* (figs. 7 and 8).

Abdomen yellowish gray marked with a dusky median stripe and several narrow cross bands; towards the tip armed with numerous short black spines.

Holotype male.

Texas: Austin, March 12 to 18, 1903, J. H. Comstock, coll.

Alabama: University, Nov. 25, 1910, 1♂; Silas, Feb. 19, 1912, 1♂; McGus, Montgomery Co., Dec. 24, 1915, 1♂, Smith, coll.

Genus **MICROHEXURA** Crosby and Bishop

Microhexura montivagus Crosby and Bishop

North Carolina: Mt. Mitchell, 6600 feet, Oct. 22, 1923. 1♂ and 2♀, immature.

Sub-order ARANEAE VERAE

Family HYPOCHILIDAE

Genus **HYPOCHILUS** Marx

Hypochilus thorelli Marx

North Carolina: Mt. Mitchell road, 4500 feet, Oct. 21, 1923, several immature specimens; Grandfather Mt., near summit, Oct. 12, 1923, immature.

Georgia: Tallulah Falls, July 20, 1909, 4♀, Bradley, coll.; August, 1867, 1♂, L. M. Underwood, coll.

Kentucky: Pine Mt., Bell Co., 2200 feet, Aug. 12, 1919, 2♀, Funkhouser, coll.

Alabama: Gallant, June 1911, 9♀, Smith, coll.

Tennessee: Lookout Mt., Sept., 1888, 2♀, Underwood, coll.; Knoxville, July 15, 2♀, Cartwright, coll.

Family ULOBORIDAE

Genus **HYPTIOTES** Walckenaer

Hyptiotes cavatus Hentz

North Carolina: Walnut Creek, Raleigh, Oct. 26, 1923, 1♀; Blowing Rock, Oct. 10, 1923, 1♀; Mt. Pisgah, Oct. 19, 1923, 2♀.

Tennessee: Beersheba, June, 1♀, Fox, coll.

Genus **ULOBORUS** Latreille

Uloborus americanus Walckenaer

North Carolina: Madison, Oct. 8, 1923, 2 immature.

Virginia: Alberta, Oct. 27, 1923, 2 immature; Rocky Mount, Oct. 8, 1923, 1 immature.

Alabama: Elrod, July 9, 1911, 1♀; University, July 15, 1911, 1♀, Smith, coll.

Uloborus geniculatus Olivier

Florida: Rockledge, March 13, 1925, 1 ♀, Hartman, coll.
Louisiana: Baton Rouge, Mar. 20, 1903, 2 ♀, Comstock, coll.

Family DICTYNIDAE

Genus AMAURORIUS C. Koch

Amaurobius bennetti Blackwall

North Carolina: Grandfather Mt., Oct. 12, 1923, 1 ♀.

The three new species described below together with *A. tibialis* Emerton (figs. 18–20) form a compact group which is characterized by the elaborate development of the tibial armature on the palpus of the male. The cribellum is undivided. The group is a natural one and probably deserves generic rank but we hesitate to propose a new genus for it without studying the related exotic forms.

Amaurobius armipotens n. sp. Figs. 9–11

Male. Length, 3.8 mm. Cephalothorax dusky yellowish, smooth and shining. Anterior eyes in a slightly procurved line, the median much smaller than the lateral, separated by the diameter and from the lateral by a little less than twice the diameter. Posterior eyes in a slightly procurved line, the median a little smaller than the lateral, separated by a little more than the diameter and a little farther from the lateral. Clypeus a little narrower than the diameter of an anterior lateral eye.

Sternum dusky yellow, clothed sparsely with black hairs, produced somewhat posteriorly between the coxae, the latter not widely separated. Coxae a little lighter. Labium and endites yellowish brown, lighter distally. Legs with the femur and patella light yellowish, distal segments brownish. Palpi very light yellowish. Chelicerae reddish brown, lower margin of the furrow armed with 4 small teeth.

Abdomen above brown, minutely dotted with white and marked with a double row of large irregular white spots. Underside of abdomen lighter brown with the usual longitudinal whitish lines. Cribellum entire.

Tibia of palpus hollowed out and produced dorsally into an extremely long, flat, rather broad, knife-shaped process which is bent at a right angle so that the tip lies diagonally across the base of the cymbium and rests in a shallow groove (fig. 9). The tip of the process is broader

than in *hoplomachus* and *hoplites;* it is thinner and more transparent; the flutings are more prominent. On the outer side of the tibia there is a very large process which extends farther than in *hoplomachus;* it bears on the inner upper margin a strong recurved spur which curves backward so that the tip almost touches the quadrate dorsal tooth.

Female. Length, 3.8 mm. Similar to the male in form and color. The legs less strongly spined. Lower margin of the chelicerae armed with 4 teeth, the proximal one larger than the others. Epigynum much like that of *hoplites* but the opening is a little larger and farther forward (fig. 11).

Holotype male, allotype female and numerous specimens of both sexes, Grandfather Mountain, N. C., Oct. 12, 1923.

North Carolina: Blowing Rock, Oct. 10, 1923, 1♂ and 4♀. Collected by sifting leaves under laurels in dense woods.

Amaurobius hoplites n. sp. Figs. 12–14

Male. Length, 3.8 mm. Cephalothorax dusky yellowish, smooth and shining. Anterior eyes in a slightly procurved line, the median much smaller than the lateral, separated by the diameter and from the lateral by twice the diameter. Posterior eyes in a slightly procurved line, subequal, the median separated from each other by about the diameter and a little farther from the lateral. Clypeus as wide as the diameter of an anterior lateral eye.

Sternum dusky yellow, clothed sparsely with black hairs, produced somewhat posteriorly between the coxae; the latter not widely separated. Coxae a little lighter. Labium and endites light reddish brown, lighter distally. Legs with the femur and patella light yellowish, distal segments brownish. Palpi very light yellowish. Chelicerae reddish brown, lower margin of the furrow armed with 4 small teeth.

Abdomen above light gray with a very fine network of light lines and two rows of indistinct, rather large light spots; median light stripe either absent or reduced to a narrow line. Underside of abdomen dirty yellow, lighter than above, the parallel light lines variable in distinctness. Cribellum entire.

Tibia of palpus hollowed out and produced into an extremely long curved, slender, sickle-shaped process which is armed on the inner concave side with a large, sharp, recurved hook (fig. 12). In *hoplomachus* the basal part of this process is swollen and light in color; in *hoplites* it is evenly and gradually widened towards the base and is uniform in color. The hook on the inner side of process is more tri-

angular and broader at the base than in *hoplomachus*. The tip of the process is thin, flattened and marked with transverse flutings as in *hoplomachus*. The distal lateral angle produced as in *hoplomachus* except that the process is more rounded distally and the spur on the upper margin is longer; the tip almost reaches the tip of the triangular dorsal tooth. The latter is longer and broader.

Female. Length, 3.5 mm. Similar to the male in form and color. The legs less strongly spined. Lower margin of the furrow of the chelicera with 4 teeth of which the proximal is the largest.

Epigynum with the lateral lobes rounded instead of square as in *hoplomachus*. The lobes are contiguous with the opening in front of them (fig. 14).

Holotype male; allotype female and numerous paratypes of both sexes.

North Carolina: Montreat, Oct. 16, 1923, collected by sifting leaves in dense woods.

Amaurobius hoplomachus n. sp. Figs. 15–17.

Male. Length, 3.5 mm. Cephalothorax dusky yellowish, smooth and shining. Anterior eyes in a slightly procurved line, the median much smaller than the lateral, separated by less than the diameter and from the lateral by twice the diameter. Posterior eyes in a slightly procurved line, subequal; the median separated from each other by the diameter and from the lateral by a slightly greater distance. Clypeus narrower than the diameter of an anterior lateral eye.

Sternum dusky yellow clothed sparsely with black hairs, produced somewhat posteriorly between the coxae, the latter not widely separated. Coxae a little lighter. Labium and endites light reddish brown, lighter distally. Legs with the femur and patella light yellowish, distal segments brownish. Palpi very light yellowish. Chelicerae reddish brown, lower margin of the furrow armed with 4 or 5 small teeth.

Abdomen above dark gray with a basal, median, lanceolate light stripe and many small light dots. Underside of abdomen with two longitudinal, light lines; between the lines lighter than above. Cribellum entire. Tibia of palpus hollowed out and produced dorsally into an extremely long, curved, slender, sickle-shaped process which is armed on the inner concave side with a small sharp recurved hook; the tip is flattened and transversely fluted. On the outside, the tibia is produced into a very large quadrate process armed on the upper, inner margin with a long, strong, recurved spur. Between the dorsal

and lateral processes there is a large triangular tooth. The back of the cymbium is grooved where the dorsal process of the tibia rests on it (fig. 15).

Female. Length, 3 mm. Similar to the male in form and color. The legs less strongly spined. Lower margin of the furrow of the chelicera armed with 5 teeth of which the proximal is the largest.

Epigynum large for the size of the spider; the lateral lobes reddish brown, shining, convex, rounded without a middle lobe (fig. 17).

Holotype, male; allotype, female.

The types and numerous paratypes, Mt. Pisgah, N. C., Oct. 19, 1923. Collected by sifting leaves in dense woods.

Genus DICTYNA Sundevall

Dictyna foliacea Hentz

Georgia: Dewitt, Mar. 1913, 1♂, Spooner, coll.; Atlanta, May 27, 1912, 1♂, 1♀.

Genus LATHYS Simon

Lathys foxii Marx

North Carolina: Blowing Rock, Oct. 10, 1923, 1♀.

Genus SCOTOLATHYS Simon

Scotolathys maculata Banks

North Carolina: Madison, Oct. 8, 1923, 5♀; Walnut Creek, Raleigh, Oct. 26, 1923, 10♂ and 9♀. Sifting under loblolly pine.

Georgia: Billy's Island, Okefinokee Swamp, June 4, 1912, 1♂ and 50♀. Sifting in hammock.

Family OECOBIIDAE

Genus OECOBIUS Lucas

Oecobius parietalis Hentz

District of Columbia: Washington, April 15, 1913, 1♂.

Louisiana: New Orleans, March 1903, 1♂ and 2 immature; Baton Rouge, March 21, 1903, 4♀, J. H. Comstock, coll.

Family FILISTATIDAE

Genus **FILISTATA** Latreille

Filistata hibernalis Hentz

Alabama: University, April 1914, 2♀; Feb. 11, 1910, 1♂; July 15, 1917, 1♂; April 1, 1915, 1♂; July 29, 1916, 1♂, Smith, coll.; May 1916, 1♂ and 1♀; Barbour Co., 1915, 1♀, Burke, coll.; Matthew's Landing, Alabama River, July 1917, 1♂ immature.

Florida: Rockledge, March 13, 1925, 1♂, 2♀, Hartman, coll.

Family LEPTONETIDAE

Genus **LEPTONETA** Simon

Leptoneta silvicultrix Crosby and Bishop

North Carolina: Oteen, Oct. 15, 1923, 2♂ and 3♀; Minehole Gap, Buncombe Co., Oct. 17, 1923, 1♀; Blowing Rock, Oct. 10, 1923, 2♂ and 1♀; Montreat, Oct. 16, 1923, 1♂.

Family OONOPIDAE

Genus **ORCHESTINA** Simon

Orchestina saltitans Banks

Mississippi: University, Aug. 1♂.

Missouri: Columbia, June 8, 1905, 1♂. Taken in sweeping.

Family DYSDERIDAE

Genus **ARIADNA** Audouin

Ariadna bicolor Hentz

Alabama: Matthew's Landing, Alabama River, July 1917, 1♀.

Family GNAPHOSIDAE

Genus **CALLILEPIS** Westring

Callilepis imbecilla Keyserling

Virginia: Top of Blue Ridge near Roanoke, Oct. 7, 1923, 1♀.

Genus **CESONIA** Simon

Cesonia bilineata Hentz

North Carolina: Stony Mt. near Hendersonville, Oct. 18, 1923, 1 young; Yadkinville, Oct. 9, 1923, 1 young; Walnut Creek, Raleigh, Oct. 26, 1923, 1 young.

Genus **DRASSYLLUS** Chamberlin

Drassyllus frigidus Banks

North Carolina: Oteen, Oct. 15, 1923, 1♂ and 1♀.

Drassyllus rufulus Banks

Alabama: Epes, Jan. 10, 1913, 2♀, Smith, coll.

Genus **HERPYLLUS** Hentz

Herpyllus vasifer Walckenaer

Maryland: Chestertown, July 1, 1924, 1♀, Hartman, coll.

Genus **ZELOTES** Gistl

Zelotes subterreaneus C. Koch

Alabama: Magnolia Spring, Baldwin Co., Feb. 5, 1912, 1♂, 1♀, Smith, coll.

Family THERIDIIDAE

Genus **ANCYLORRHANIS** Simon

Ancylorrhanis hirsutum Emerton

North Carolina: Oteen, Oct. 15, 1923, 3♂ and 3♀; Mt. Pisgah, Oct. 19, 1923, 3♂ and 8♀; Minehole Gap, Buncombe Co., Oct. 17, 1923, 2♂ and 4♀.

Virginia: Blue Ridge Mt. near Roanoke, Oct. 7, 1923, 1♂ and 1♀; Alberta, Oct. 27, 1923, 2♀.

Genus **ARGYRODES** Simon

Argyrodes cancellatus Hentz

Virginia: Alberta, Oct. 27, 1923, 1♀.

Argyrodes nephilae Taczanowski

Alabama: Hall Lake, Tuscaloosa Co., July 29, 1911, 1 ♀, Smith, coll.

Argyrodes trigonum Hentz

North Carolina: Madison, Oct. 8, 1923, 2 ♀, young; Oteen, Oct. 15, 1923, 1 ♀, young; Yadkinville, Oct. 9, 1923, 1 young.

Virginia: Maurertown, Oct. 5, 1923, 1 ♀, young; Alberta, Oct. 27, 1923, 1 ♀, young.

Alabama: Forks of Warrior River, Walker Co., Oct. 20, 1912, 1 ♀, Smith, coll.

Genus **ASAGENA** Sundevall

Asagena americana Emerton

North Carolina: Oteen, Oct. 15, 1923, 1 ♂, young.

Virginia: Alberta, Oct. 27, 1923, 1 ♂.

Genus **CRUSTULINA** Menge

Crustulina guttata Wider

North Carolina: Oteen, Oct. 15, 1923, 1 ♂.

Genus **DIPOENA** Thorell

Dipoena intrita n. sp. Fig. 21

Male. Length, 1.8 mm. Cephalothorax light orange-yellow, a square area in front of the median furrow lighter; a distinct black spot includes the eye-area and extends half way down the clypeus. Anterior eyes in a nearly straight row, the median larger than the lateral, separated from each other by one and one-half times the diameter and from the lateral by the radius. Posterior eyes in a straight line, equal and equidistant, smaller than the anterior median.

Clypeus twice as wide as the diameter of an anterior eye. Sternum yellowish, labium and endites dark reddish. Coxae paler than the sternum. Labium longer than wide. Hind coxae separated by the diameter of a coxa. Legs and palpi pale yellowish white. Chelicerae orange-yellow, darker distally.

Abdomen above opaque white, rather thickly clothed with long light colored hairs; underside light yellowish white. A large yellowish plate in front of the epigastric furrow. Tarsus of palpus rather short. The embolus arises from a bulb-like base on the lateral side of the bulb and

curves backward across the face of the bulb and then follows the edge of the cymbium to near the tip of the palpus (fig. 21). At the tip of the bulb there are two processes, one rather slender and sharp-pointed; the other is thin and folded over lengthwise so as to protect the tip of the embolus which lies between the two parts.

Georgia: Billy's Island, Okefinokee Swamp, June 1912, 2♂, one of them teneral.

Dipoena nigra Emerton

Virginia: Alberta, Oct. 27, 1923, 1 young.

Genus **EPISINUS** Latreille

Episinus truncatus Latreille

North Carolina: Montreat, Oct. 16, 1923, 1♂, young.

Genus **LATRODECTUS** Walckenaer

Latrodectus mactans Fabricius

North Carolina: Oteen, Oct. 15, 1923. Several of both sexes under stumps and stones in dry pasture; Grandfather Mt., Oct. 12, 1923, 4200 feet, 3♂.

Virginia: Strassburg, Oct. 5, 1923, 1♀.

Alabama: Epes, Jan. 12, 1914, 1♂ and 1♀; Jan. 10, 1913, 1♂, 1♀; Gallant, June 1911, 1♀; Holt, Dec. 25, 1912, 1♀; Magnolia Springs, Feb. 5, 1912, 2♂ and 3♀; Foley, Jan. 25, 1912, 10♀; University, June 15, 1913, 1♀; May, 1♀; Three Island Shoals, Coosa River, Talladaga Co., Nov. 10, 1911, 1♀; Livingston, Jan. 5, 1913, 1♂ and 3♀; Elrod, Tuscaloosa Co., July 9, 1911, 1♀, Smith, coll.

Mysmena guttata Banks. Fig. 22

Microdipoena guttata Banks.

Male. Length, 0.9 mm. Cephalothorax yellowish, narrowly margined with black. The anterior median eyes in an oval black spot. Head greatly elevated. Seen from the side the cephalothorax rises to the posterior eyes in an even gentle arch over the back. Clypeus very wide, strongly concave below the eyes and slightly retreating.

Anterior eyes in a slightly procurved line, equal, the median separated by the diameter and a little nearer to the lateral. Posterior eyes in a slightly recurved line; the median somewhat angulate, larger than

the lateral and separated by about the radius and a little farther from the lateral. Median ocular area as wide as long and a little wider in front than behind.

Sternum, labium, endites and coxae yellowish. Sternum broadly rounded behind between the coxae which are separated by the length of one of them. Chelicerae yellowish, shorter than the width of the clypeus.

Legs pale, banded indistinctly with dusky as follows: base of femora, distal half of tibiae and metatarsi. Palpus pale.

Abdomen gray, the tip lighter, marked above with five pairs of small white spots, and on each side with two small spots; underside gray in front and lighter behind.

Femur of palpus moderately long and gently widened distally. Patella short and stout, only a little longer than wide. Tibia short, very wide distally, deeply excavated for the insertion of the tarsus, the margin armed with a series of very long curved spines. The cymbium is on the ventral side of the bulb, broad at base, but gradually narrows towards the tip where it is deeply notched for the passage of the embolus. The tip is very thin and almost membraneous. The bulb is very large. The embolus arises at the middle of the bulb on the dorso-lateral side and passes entirely around the middle of the bulb, under the cymbium; it then crosses itself and follows the edge of the cymbium and the tip of the palpus where it has a light colored section and is joined by the ejaculatory duct. The terminal part of the embolus makes one complete spiral turn around the tip of the palpus and lies in the notch in the tip of the cymbium (fig. 22).

North Carolina: Oteen, Oct. 15, 1923, 1♂.

Georgia: Billy's Island, Okefinokee Swamp, June 4, 1912, 2♂ and 2♀, young. Sifting in hammock on edge of swamp.

The species is very closely related to *M. leucoplagiata* Simon, the type of the genus, with which we have compared it.

PAIDISCA n. gen.

Type, *Histagonia marxi* Crosby

Related to *Histagonia* Simon from which it differs in having distinct teeth on the paired claws of the tarsus and in having the sternum broadly produced between the hind coxae. Male provided with a stridulating organ between the abdomen and cephalothorax. Chelicera nearly parallel, upper margin of the furrow provided with an angular projection preceded by an obtuse lobe; lower margin unarmed. Abdomen armed with chitinous sclerites.

Paidisca marxi Crosby. Figs. 23–27

Histagonia marxi Crosby. Can. Ent. **38:** 309, figs. 35–36. 1906.

Ulesanis serrata Emerton. Conn. Acad. Sci. Trans. **18:** 213, pl. 1, fig. 5. 1913.

Male. Length, 1.1 mm. Cephalothorax clothed with scattered, small spine-bearing tubercles most abundant on the sides; bright orange yellow; viewed from above, evenly rounded on the sides behind, the sides strongly convergent towards the front. The lateral eyes protuberant and the anterior median eyes borne on the corners of a short quadrate projection of the head; viewed from the side, steeply ascending behind and then gently arched over to the posterior eyes. Clypeus strongly concave under the eyes and convex below, strongly retreating. Posterior eyes in a recurved line, equidistant, separated by a little less than the diameter; the median a little larger than the lateral, subtriangular, the inner margin straight, pointed behind. Anterior eyes in a straight line, equidistant, separated by a little less than the diameter; the median a little smaller than the lateral. A long stiff, curved hair arises on each side between the posterior median and the lateral eyes and projects forward over the anterior median eyes. Below and between the anterior median eyes there is an obtuse protuberance. On the disk of the cephalothorax there are six stiff hairs directed forward; the first two are in the median line and the other four in pairs, the hind ones farther apart. Sternum bright orange yellow, sparsely clothed with stiff dark hairs, broader than long, broadly produced between the hind coxae and inflexed at tip. Hind coxae separated by twice their diameter. Endites long and strongly convergent. Chelicerae nearly parallel, upper margin of the furrow provided with an angular projection, bidentate at tip and preceded by an obtuse lobe; lower margin unarmed. Legs and palpi orange-yellow, reddish on femora and tibiae. Femur of first leg enlarged and armed below with a series of seven to nine long, strong spines (fig. 25). Metatarsus a little longer than tarsus. The paired claws armed near the middle with one fair sized tooth and with a few smaller teeth toward the base (fig. 27). The third claw with a small tooth near the middle. Abdomen provided with a large, strongly chitinized dusky orange-yellow sclerite which covers all but the tip. The sclerite covered with numerous short, appressed hairs arising from minute tubercles. Epigastric sclerite completely surrounding the pedicle and laterally extending back of the furrow as two curved round-pointed lobes. The epi-

gastric plates smooth, broadly oval, truncate behind (fig. 26, e.p.). On each side just in front of the pedicular foramen there is a series of four minute denticles which are apposed to a series of ridges on the posterior margin of the cephalothorax and form a stridulating organ (fig. 26, s.o.). Inframammilliary sclerite a rather broad band surrounding the spinnerets.

Female. Length, 1.1 mm. Much like the male in color, but lacks the dorsal abdominal sclerite. The cephalothorax is not so strongly prominent in the eye region; the anterior eyes not being borne on protuberances, are much closer together. The anterior femora neither enlarged nor armed with a series of spines. The epigynum consists of a large convex sclerite, the posterior margin of which is raised into a thin, transverse, nearly vertical plate, which bears a very small obtuse tooth at the middle. The ducts are united in front of the opening, which is small, round, and situated on the inner side of the plate near its posterior margin (fig. 24). This species was described from Tennessee and the District of Columbia. Emerton redescribed it from Connecticut.

North Carolina: Oteen, Oct. 15, 1923, 2♂ and 3♀; Mt. Pisgah, Oct. 19, 1923, 4♀; Raleigh, Oct. 26, 1923, 1♂ and 2♀.

Virginia: Alberta, Oct. 27, 1923, 1♂; Falls Church, 1♂, Banks, coll.

New York: Riverhead, Apr. 11, 1923, 1♂ and 3♀; May 31, 1923, 3♀.

Florida: Gainesville, Feb. 12, 1925, 1 ♂ and 4 ♀, Barrows, coll.

Genus **ROBERTUS** Cambridge

Robertus riparius Keyserling

North Carolina: Mt. Mitchell, summit, Oct. 22, 1923, 1♀. Sifting moss.

Genus **RHOMPHAEA** L. Koch

Rhomphaea fictilium Hentz

Virginia: Alberta, Oct. 27, 1923, 1♀.

Genus **SPINTHARUS** Hentz

Spintharus flavidus Hentz

North Carolina: Walnut Creek, Raleigh, Oct. 26, 1923, 1♀.

Virginia: Alberta, Oct. 27, 1923, 1♀.

Genus **TEUTANA** Simon

Teutana triangulosa Walckenaer

Alabama: University, Oct. 1, 1912, 1♂, Smith, coll.

Genus **THEONOE** Simon

Theonoe stridula Crosby

Virginia: Falls Church, 1♂, Banks, coll.

Genus **THERIDION** Walckenaer

Theridion albomaculatum Cambridge

Georgia: Billy's Island, Okefinokee Swamp, June 18, 1912, 2♂ and 3♀; Thunderbolt, June 26, 1912, 2♀.

An egg-sac was found on the underside of a *Liquidamber* leaf. It is spherical, 2 mm. in diameter, and composed of fine silk, tightly woven to form a firm tissue. It contained 23 eggs.

Theridion antoni Keyserling

Tennessee: Grundy Co., June, 1♂, Fox, coll.

Theridion differens Emerton

North Carolina: Raleigh, June 30, 1912, 2♂.

Georgia: Billy's Island, Okefinokee Swamp, June 1912, 1♀; Thunderbolt, June 26, 1912, 2♂.

Theridion dimachaerum n. sp. Fig. 28

Male. Length, 2 mm. Cephalothorax pale yellowish with a broad central marking reddish in front of the dorsal groove where it expands to include the eyes, and gray behind.

Anterior eyes in a straight line, the median very slightly larger than the lateral, separated by the diameter and a little nearer to the lateral. Posterior eyes in a straight line, median a little larger than the lateral, separated by the diameter and a little farther from the lateral. Clypeus twice as wide as the diameter of an anterior median eye.

Sternum, labium, endites and legs including the coxae, pale yellow; palpus the same color, tarsus darker.

Abdomen above dull grayish with small irregular flecks of chalky white; underside white with a large, smooth pale yellowish plate in front of the epigastric furrow.

The palpal organ similar to that of *T. differens* but the roughened process on the outer side is rounded and lacks the sharp angle (fig. 28).

Holotype, male. One specimen, Billy's Island, Okefinokee Swamp, June 1912.

Theridion flavonotatum Becker. Fig. 29

Georgia: Billy's Island, Okefinokee Swamp, June 1912, 1♂ and 4♀; Honey Island, Okefinokee Swamp, June 1, 1912, 1♀.

Theridion fordum Keyserling

Alabama: Morgan Creek, Shelby Co., June 3, 1914, 1♀, Smith, coll.

Theridion frondeum Hentz

Alabama: University, July 31, 1911, 1♂; Smith, coll.

Theridion globosum Emerton

Georgia: Billy's Island, Okefinokee Swamp, June 1912, 1♂ and 2♀.

Missouri: Columbia, June, 1♂.

The male from the Okefinokee Swamp differs from the description and figure given by Emerton (1911) in having the eye area not black and the abdomen unspotted.

The female has the dorsal spot very faintly indicated.

Theridion imparatum n. sp. Fig. 30

Male. Length, 1.7 mm. Cephalothorax orange-yellow without dark markings. Anterior eyes in a straight line, equal and equidistant, separated by the radius. Posterior eyes in a straight line, equal; the median separated by the radius and a little farther from the lateral. Clypeus as wide as three times the diameter of an anterior eye.

Sternum, endites and labium pale yellow. Chelicera orange-yellow. Legs white, femora of first and second legs tinged with yellow. Abdomen above white, sparsely clothed with fine white hairs; underside white except in front of epigastric furrow where it is dirty yellow. Spinnerets yellowish.

Femur of palpus armed dorsally with a series of long spines; the patella subglobular, as thick as long and armed dorsally with several very long spines; the tibia rather short, widened, deeply excavated for the insertion of the tarsus. The embolus arises from a bulb-like base on the middle of the face of the bulb, crosses it transversely then curves forward to the tip of the bulb where it is protected by a long blade-like con-

ductor. On the mesal side of the bulb, at the tip, is a rounded process coarsely roughened (fig. 30).

Holotype, male. One specimen, Billy's Island, Okefinokee Swamp, Georgia, June 1912.

Theridion kentuckyense Keyserling

North Carolina: Yadkinville, Oct. 9, 1923, 2 young.

Theridion murarium Emerton

Louisiana: 1 ♀, Guilbeau, coll.

Theridion pictipes Keyserling

Georgia: Billy's Island, Okefinokee Swamp, June 1912, 1 ♀.

Theridion punctis-sparsum Emerton

Kentucky: Breathitt Co., June 20, 1923, 1 ♀, Funkhouser, coll.

North Carolina: Oteen, Oct. 15, 1923, 2♂; Madison, Oct. 8, 1923, 1 ♂ and 1 ♀.

District of Columbia: Oct. 2♂ and 4 ♀, Fox, coll.

Theridion rupicola Emerton

Tennessee: Beersheba, July 1888, 2 ♀, Fox, coll.

North Carolina: Oteen, Oct. 15, 1923, 1♂ and 3 ♀, young.

Theridion sexpunctatum Emerton

North Carolina: Summit of Mt. Mitchell, Oct. 22, 1923, 1♂, young. Sifting moss.

Theridion spirale Emerton

Georgia: Billy's Island, Okefinokee Swamp, June 1912, 1♂; Thomasville, May 31, 1914, 1♂, C. S. Spooner, coll.

Theridion studiosum Hentz

Georgia: Billy's Island and Mixon's Hammock, Okefinokee Swamp, June 1912, 2♂ and 8♀. In a tangled sheet web 5 or 6 inches long on end of branch 4 or 5 feet from the ground at edge of swamp. Much dirt in web.

Theridion unimaculatum Emerton

Georgia: Billy's Island, Okefinokee Swamp, June 1912, 1♂.

Genus **THERIDULA** Emerton

Theridula opulenta Walckenaer

North Carolina: Blowing Rock, Oct. 10, 1923, 2 ♀, young; Raleigh, June 30, 1912, 1 ♂.

Kentucky: Pine Mt., Bell Co., Aug. 12, 1919, 2200 feet, 1 ♀, Funkhouser, coll.

Genus **ULESANIS** L. Koch

Ulesanis americana Emerton

North Carolina: Blowing Rock, Oct. 10, 1923, 1 ♀.

Family CLUBIONIDAE

Genus **ANAHITA** Karsch

Anahita punctulata Hentz. Figs. 31–33

Male. Length, 5.5 mm. Cephalothorax with a light yellowish stripe extending from the posterior eyes to the hind margin, slightly constricted in front of the dorsal groove, bordered on each side by a broad brownish band with irregular outer edges; marginal band pale with indistinct dusky patches; extreme margin black. The two eyes of the front row separated by less than the diameter. The second row of eyes in a straight line, the median much larger than the lateral, separated from each other by about the diameter and from the lateral by the radius. The posterior pair of eyes larger than others, separated by three times the diameter. Clypeus as wide as the radius of an eye of the first row. Sternum, labium, endites and coxae yellowish, sparsely clothed with short brown hairs. Labium much broader than long, broadly rounded at apex. Endites narrow at base, the main part rectangular, square across at tip. The truncate margin short, clothed with long soft yellowish hairs.

Chelicerae yellowish with a short vertical black line in front at base. Upper margin of the furrow armed with one large and two small teeth, the middle one the largest; lower margin with three large and two or three small teeth. Legs dusky yellow, underside of femora with a few small grayish spots. Abdomen above pale yellowish white with a pair of narrow broken, parallel longitudinal brown lines, and with numerous small irregular brown spots. Underside the same with a few small spots.

Femur of palpus long, slender, cylindrical and almost straight, armed above near the tip with a transverse row of four strong spines and a

median row of four spines. Patella moderately long and stout, armed on the mesal side near base with one strong spine. Tibia one and one-half times as long as patella, slightly widened distally, armed above with three strong spines, two towards the base and one on the lateral face at the distal third. On the dorso-lateral angle there is a short, sharp-pointed spine borne on a distinct tubercle. Below this there is on the lateral aspect, a marginal row of 5 slender spines and on the ventral margin another row of 6 or 7 (fig. 32).

The embolus arises near the lateral edge of the bulb and curves back towards the base and follows the edge of the cymbium around the tip of the tarsus. On the face of the bulb there arises a long, flat process which extends towards the tip of the tarsus beyond the edge of the cymbium; the end is incurved and squarely truncate. Between the process and the bulb there lies a delicate membrane (fig. 31).

Female. Length, 8 mm. Similar to the male in coloration. The lines on the abdomen more broken and the underside almost unspotted. Epigynum a broad flat plate. The external openings are well forward and widely separated (fig. 33).

Tennessee: Knoxville, 1♂ and 3 young, Cartwright, coll.; Lookout Mt., 1♀, Fox, coll.

Genus **ANYPHAENA** Sundevall

Anyphaena gracilis Hentz

Mississippi: Ocean Springs, Jan. 22, 1905, 2♂ and 7♀, J. H. Comstock, coll.

Georgia: Billy's Island, Okefinokee Swamp, July 1912, 1♀.

Florida: Sorrento, Feb. 1905, 2♀, P. B. Powell, coll.; Miama, Feb. 20, 1903, 1♂, J. H. Comstock, coll.

Genus **CASTANEIRA** Keyserling

Castaneira descripta Hentz

North Carolina: Oteen, Oct. 15, 1923, 1♀; Blowing Rock, Oct. 10, 1923, 1♀.

Castaneira amoena C. Koch. Fig. 34

Male. Length, 6.5 mm. Cephalothorax golden yellow, rather long, rounded on the sides, narrower towards the front, broadly rounded across the front; viewed from the sides abruptly ascending behind, flattened on top and gently rounded down to the eyes. Clypeus straight and slightly retreating.

Posterior eyes in a very slightly procurved line, equal, the median separated by the diameter and a little closer to the lateral. Anterior eyes in a very slightly procurved line, equal, the median separated by a little less than the diameter and almost touching the lateral. Median ocular area longer than broad and wider behind than in front. Clypeus one and one-half times the diameter of an anterior median eye.

Sternum light yellow, oval, longer than wide, squarely truncate in front and bluntly pointed behind. Labium and endites yellow, tinged with orange. Chelicerae bright orange-yellow with a darker U-shaped mark in front and clothed with long dark hairs.

Legs with coxae yellow; first and second legs have the femora reddish brown except at base, the remaining segments pale yellow; third and fourth legs have the femora marked with an incomplete reddish brown ring near tip, the patellae, and the tibiae with a median band; the metatarsi with a band at each end; tarsi yellow. Palpus reddish brown, distal half of tarsus lighter.

Abdomen long, oval, golden yellow marked with about seven, medially interrupted transverse darker bands. Femur of palpus rather short, straight and widened distally. Patella short, only a little longer than broad. Tibia as long as patella, excavated below for the reception of the bulb. Tarsus long, slender, tapering to a point. The genital bulb elongate, pyriform, the base smoothly rounded and conspicuously marked by the sinuous ejaculatory duct. The styliform embolus lies in a groove at the tip of the tarsus (fig. 34). Redescribed from a single male from Fort William shoals. Shelby Co., Alabama, June 27. 1914. H. H. Smith, coll.

Genus CHIRACANTHIUM C. Koch

Chiracanthium inclusum Hentz

North Carolina: Southern Pines, Aug. 15, 1902, 1 ♀.

Mississippi: Agricultural College, 1918, 1 ♀, Bailey, coll.

Georgia: Billy's Island, Okefinokee Swamp, June 1912, 2 ♂.

District of Columbia: Oct. 1 ♀, Fox, coll.

Florida: Lake City, Mar. 1903, 1 ♂, young; Miami, Feb., Mar. 1903, 1 ♀, Comstock, coll.

Louisiana: Baton Rouge, March 20, 1903, 1 ♂, Comstock, coll.

Alabama: University, May 24, 1913, 1 ♀; Elrod, July 9, 1911, 1 ♂, Smith, coll.

Genus CLUBIONA Latreille

Clubiona abboti L. Koch

Tennessee: Knoxville, July 28, 1 ♀, Cartwright, coll.

Clubiona pallens Hentz

North Carolina: Oteen, Oct. 15, 1922, 1 ♀; Blowing Rock, Oct. 10, 1923, 1 ♂; Bridgewater, Oct. 14, 1923, 1 ♂.
Alabama: Gallant, June 1911, 1 ♀, Smith, coll.

Clubiona tibialis Emerton

Georgia: Billy's Island, Okefinokee Swamp, June 1912, 2 ♂ and 1 ♀; May 25, 1921, 1 ♀, Wright and Harper, coll.

Genus CTENUS Walckenaer

Ctenus hybernalis Hentz. Figs. 35–36

Male. Length, 14 mm. Cephalothorax reddish-orange with a broad light median stripe, clothed with soft light pubescence and a few dark hairs; viewed from above rather long, evenly rounded on the sides, slightly constricted at the cervical groove; rounded truncate in front; viewed from the side, abruptly ascending behind, highest back of the middle, nearly flat over the back to the posterior eyes. The front slightly protruding below.

Posterior eyes in a strongly recurved line, equal, the median separated by a little less than the radius and from the lateral by the diameter. Anterior eyes in a very strongly recurved line, all smaller than the posterior. The median very slightly larger than the lateral, separated by a little less than the diameter and from the lateral by the diameter. The anterior lateral eyes in line with the posterior median and in front of the lateral; separated from the former by the radius and from the latter by nearly the diameter. Median ocular area as wide as long, wider behind than in front. Clypeus a little narrower than diameter of an anterior median eye.

Sternum orange-yellow, sparsely clothed with stiff dark hairs, interspersed with numerous fine hairs thicker near margin; regularly oval, the margin crenulate, round pointed behind. The hind coxae subcontiguous. Labium strongly convex, sparsely clothed with strong black hairs, the tip with an irregular row of stiff hairs, quadrate, longer than broad, excavated on the sides at base, truncate at apex with the

corners rounded. Endites pointed at base, rounded, dilated at tip, straight on the inner margin, excavated at the insertion of the trochanter and sparsely clothed with stiff hairs, larger on the lateral margin. The entire truncate margin of the endite clothed with a dense fringe of long soft yellow hairs. Chelicerae reddish orange, face densely clothed with long, dark, strong hairs except at the base. Upper margin of the furrow armed near the tip of the claw with three large and one small teeth; lower margin with four large and one small.

Legs same color as the cephalothorax, darker distally. Abdomen elongate oval, greenish gray with a broad median dull yellow stripe narrower behind, where it is deeply notched on the side; the apex of each point marked with a group of short white hairs. Underside of abdomen dirty yellow in front of the epigastric furrow, the remainder gray with two pairs of converging light lines and on the sides marked with numerous small light spots.

Femur of palpus slightly curved, cylindrical, slender at base somewhat widened distally, armed above near tip with a transverse row of four strong spines and with two spines on the middle line. Patella straight, slightly widened distally, armed with a large spine on the mesal face just back of the middle. Tibia a little longer than patella, armed towards the base with two dorsal and one mesal spines, widened distally and provided with a broad stout dorso-lateral apophysis which is curved inward and laterally at tip and bears dorsally a quadrate tooth. The tarsus is short, densely clothed with fine yellowish hair and armed on the mesal angle with one spine. On the face of the bulb there are two processes, the basal one (median apophysis) is broad, incurved and rounded at tip, the other, the embolus, is curved and with the end somewhat dilated; on the inner side there are two deep rounded notches separated by a blunt tooth (fig. 35).

Female. Length, 20 mm. Similar to the male in form and color. Epigynum a broad convex lobe, widest behind, the sides bounded by curved chitinous ridges (fig. 36).

Alabama: Holt, Mar. 25, 1912, 1 ♀; Magnolia Springs, Feb. 5, 1912, 2 young; Hagler, Mar. 18, 1912, 1 ♀; Apr. 25, 1912, 3 ♀; Indian Creek, Tuscaloosa Co., Apr. 15, 1912, 1 young; Warrior River, Jefferson Co., Apr. 11, 1912, 1 ♂, 8 ♀; Pratts Ferry, Bibbs Co., June 1912, 1 ♂; University, June 15, 1913, 1 ♀; Three Island Shoals, Coosa River, Talladaga Co., Nov. 14, 1911, 1 ♀; Cottondale, July 1912, 1 ♀; Matthew's Landing, Alabama River, July 1917, 1 young; Eoline, Bibb Co. Apr. 26, 1912, 1 ♂, Smith, coll.

Genus GAYENNA Nicolet

Gayenna maculata Banks. Figs. 37–38

Male. Length, 4 mm. Cephalothorax pale yellowish white with a blackish narrow line extending back from each posterior eye, the two lines on each side uniting about half way from the eyes to the dorsal groove to form a broad stripe with irregular margins that reach nearly to the hind margin of the thorax. Margin of cephalothorax with a narrow black line. Anterior eyes in a slightly recurved line, equidistant, the median about two-thirds the diameter of the lateral, separated by less than half the radius. Posterior eyes in a straight line, the median a little smaller and nearer to the lateral than to each other, separated by about their diameter. Clypeus with a broad black margin, about as wide as the diameter of an anterior eye.

Sternum pale yellowish white, dusky along the margin with a triangular mark opposite each coxa. Labium pale, brownish on the sides; endites and coxae pale. Coxae of third and fourth legs armed anterioventrally with numerous small black tooth-like spines pointed backwards. Chelicerae marked in front on the basal two-thirds with two dark lines enclosing a diamond-shaped area open at the base; lower margin of the furrow armed with eight very small teeth.

Legs pale yellowish white in ground color darker distally, ringed with dark gray; incomplete bands at middle and tip of femur, at the base of tibia, at base of metatarsus; on the underside the markings are more blotched. Palpus light, tarsus reddish.

Abdomen dingy white in ground color marked with black. A lanceolate basal light mark bordered on the anterior angles with a distinct black area and on the side by broken black stripes which unite behind to form a conspicuous median stripe. This stripe is narrowly interrupted by pale chevrons. Sides of abdomen spotted and blotched with black. Underside grayish white with a black spot in front of the genital opening and a smaller one in front of the tracheal spiracle; behind the spiracle a median spot sometimes broken into two, on the sides a few small scattered spots.

Tibia of palpus armed ventrally on the basal half with a large rounded protuberance somewhat larger than in *G. celer*. At the tip on the outer upper angle there is a large two-branched apophysis (fig. 37). The inner branch is triangular and bluntly pointed, more slender than in *G. celer*. The outer branch is longer than the inner branch; seen from the side flattened and wider distally, and rounded at tip; viewed endwise

it seems to terminate in a thin plate folded nearly double. In *celer* the outer is no longer than the inner branch and the tip is broadly hollowed out on the inside giving it a bilobed appearance when viewed from the side.

Female. Length, 4.5 mm. Similar to male in form and color. The coxae of the third and fourth legs lack the patches of small spines. Epigynum has the thickened basal part of the median lobe more transversely oval then in *G. celer*; the posterior part is longer and broader towards the tip.

North Carolina: Oteen, Oct. 15, 1923, 2 ♂; Madison, Oct. 8, 1923, 1♂, 1♀.

D. C.: Oct. 2♂, 4♀, Fox, coll.

Gayenna pectorosa L. Koch

Tennessee: Lookout Mt., July, 1♂, Fox, coll.

Genus PHRUROLITHUS C. Koch

KEY TO SPECIES OF PHRUROLITHUS OF THE EASTERN UNITED STATES[1]

Males

1. Sternum with a dark median stripe.....*umbratilis* n. sp.
   Sternum without a dark median stripe..... 2
2. Tibial apophysis with branch at tip.....*minutus* Banks
   Tibial apophysis without branch at tip..... 3
3. Femur of palpus with a distinct knob below..... 4
   Femur of palpus with a low hump below..... 6
4. Femur of palpus with the knob near middle....(*Phruronellus*) *formica* Banks
   Femur of palpus with the knob near base..... 5
5. Tibial apophysis with the ventral branch long; femora of legs not lined with black.....(*Phruronellus*) *pugnatus* Emerton
   Tibial apophysis with the ventral branch short; femora lined with black (*Phruronellus*) *similis* Banks
6. Tibial apophysis narrow and pointed at tip.....*palustris* Banks
   Tibial apophysis broad..... 7
7. Tibial apophysis excavated at tip.....*alarius* Htz.
   Tibial apophysis not excavated.....*paludivagus* n. sp.

[1]Chamberlin, R. V. (Can. Ent. **53**: 69. 1921) proposes the generic name *Phruronellus* for several species heretofore included in *Phrurolithus*. The males in these species are characterized by the development of a distinct knoblike apophysis on the femur of the palpus below, by having the tibial apophysis composed of two branches united at the base and by the uniform coloration of the cephalothorax. The species which fall within this group, according to Chamberlin's definition, are indicated in the key.

Females

1. Sternum dark (gray or brown)..... 2
   Sternum light, with or without a dark central stripe..... 5
2. Cephalothorax dark, no light stripes..... 3
   Cephalothorax dark with a light median band..... *minutus* Banks
3. Venter of abdomen light..... 4
   Venter of abdomen dark; receptacles of epigynum rounded, separated by their diameter; abdomen above dark gray with dirty white markings (*Phruronellus*) *pugnatus* Emerton
4. A small dark spot in front of spinnerets; abdomen above strongly banded. Femur sometimes with longitudinal dark stripes (*Phruronellus*) *similis* Banks
   Two fine dark lines from epigynum to spinnerets, abdomen above indistinctly banded..... (*Phruronellus*) *formica* Banks
5. Sternum with dark central stripe..... *umbratilis* n. sp.
   Sternum without a dark central stripe..... 6
6. Legs strongly banded..... 7
   Legs not strongly banded, receptacles of epigynum more than the diameter apart..... *alarius* Htz.
7. Venter of abdomen with three short dark bars..... *paludivagus* n. sp.
   Venter of abdomen with two small dark spots midway between epigynum and spinnerets..... *palustris* Banks

Phrurolithis alarius Hentz

Phrurolithis borealis Emerton.

We believe that the figure and description given by Hentz refers to the species described and figured by Emerton as *P. borealis* (Trans. Conn. Ac. **16**: 404. 1911), in which the receptacles of the epigynum are more than their diameter apart. Hentz apparently had the female only. In the figure the pattern on the abdomen is exactly like that of dark specimens of this form and does not even suggest the markings of the other form, in which the receptacles are less than the diameter apart. On the cephalothorax the dark marking is shown extending to the margin without any submarginal light line. We have not seen any specimens in which this is strictly true but the dark band is wider and extends nearer to the margin in Emerton's *borealis* than in the other form. This is the form which Comstock (Spider Book, p. 576, 1912) figures and describes as *alarius*.

Missouri: Columbia, June 1906, 1 ♀.

Alabama: University, June 15, 1913, 1 ♀, Smith, coll.

Phrurolithus formica Banks

North Carolina: Blowing Rock, Oct. 10, 1923, 1♂. Sifting.
Missouri: Columbia, April, 1905, 1♀; May, 1♀. In ants' nest.
District of Columbia: Apr., May, Oct.

Phrurolithus paludivagus n. sp. Figs. 39–40

Male. Length, 2.4 mm. Cephalothorax with an orange-yellow area extending from the eyes backward and including the median groove, the rest of the carapace suffused with gray and with darker, irregular, radiating lines. Carapace narrowly margined with black, continuous across the clypeus which is lighter below the eyes.

Anterior eyes in a procurved line, the median a little larger than the lateral, separated from each other by less than the radius and nearly touching the lateral. Posterior eyes in a straight line, equal, the median farther from each other than from the lateral.

Sternum light yellowish. Labium and endites yellow tinged with dusky. Coxae yellowish with dusky along the sides and at tip. Chelicerae dirty yellow ornamented in front with an oval black area containing a lighter spot in the middle and sending off a diagonal black mark to the basal outer angle of the chelicera. First leg with the femur dusky yellow, darker at the tip; patella dark above and light on each side; tibia light brown with the distal third white, armed below with a fringe of long hairs; metatarsus dusky at base and on distal third, the rest yellowish; tarsus white. Second leg with the femur yellowish with a broken dusky ring at base; patella yellowish dusky on sides; tibia yellowish, light at tip and dusky along the sides; metatarsus yellowish, slightly dusky at base; tarsus lighter. Third and fourth legs yellowish with dusky markings at base of femur, near the tip of tibia and most of the metatarsus; the tip of tibia and metatarsus lighter.

Abdomen above orange-yellow; dusky at base, becoming darker at the sides with minute spots, posteriorly dark brown and clothed with iridescent scales. Underside of abdomen yellowish in front of epigastric furrow, dirty white behind with a broad dusky stripe from the spinnerets two-thirds the way to the furrow.

Femur of palpus with a low rounded hump near tip below, clothed with a few stiff hairs. Tibia armed externally with a long flat curved process slightly constricted at middle (fig. 39).

Female. Length, 3.2 mm. Cephalothorax narrowly margined; with a broad median and submarginal stripes orange-yellow; on each

side a broad dark stripe extending from the posterior lateral eyes backward around the posterior declivity to the margin, narrowly separated behind from the line of the opposite side. Legs lighter than the cephalothorax marked with black or dusky as follows: Femora of all the legs with a narrow ring at base and a broader one near apex, all patellae with a ring at tip, tibia of first leg except extreme tip, all the other legs with a broad band in middle, all metatarsi with a band at base and middle. Tarsi of third and fourth legs with a band at base. Palpi yellowish with rings of black at base of femur, tibia and tarsus.

Abdomen above gray minutely spotted with lighter and marked posteriorly with fine chevrons; one or two white spots above the spinnerets. Underside of abdomen light gray with short parallel dark stripes back of the epigastric furrow. Epigynum with the receptacles separated by their diameter (fig. 40).

Holotype male, allotype female and 1 ♀ paratype, all from Billy's Island, Okefinokee Swamp, Ga., June 1912. Sifting in deep woods at edge of swamp.

Phrurolithus palustris Banks

Banks (Phila. Acad. Nat. Sci. Proc. 1916, p. 70) states that in his "Spiders of the Cayuga Lake Basin," 1892, the species which he considered as *P. palustris* was in reality *P. alarius* Hentz (non Emerton). This taken in connection with his other statement, "*P. alarius* (Banks det.) equals *P. borealis* Emerton" makes it clear that Banks meant his *P. palustris* was equal to the one which in 1911 Emerton placed as a synonym of *P. alarius* Hentz, that is, the form in which the receptacles of the epigynum are about their diameter apart. We believe the true *P. alarius* Hentz is the form which has the receptacles of the epigynum distinctly more than their diameter apart.

North Carolina: Blowing Rock, Oct. 10, 1923, 1 ♀; Mt. Pisgah, Oct, 19, 1923, 5 ♀; Oteen, Oct. 15, 1923, 1 ♀.

Virginia: Blue Ridge, near Roanoke, Oct. 7, 1923, 1 ♀; Rocky Mount, Oct. 8, 1923, 1 ♀; Anna River, Oct. 28, 1923, 1 ♂.

Tennessee: Lookout Mt. 2 ♂ and 3 ♀; Beersheeba, Fox, coll.

Maryland: Cabin John, Dec. 3, 1918, 1 ♀.

Missouri: Columbia, Dec. 1904, Mar. 1906, June 1905. Numerous specimens of both sexes.

Phrurolithus similis Banks

Male. Length, 2.3 mm. Cephalothorax dark brown with a darker area in front of the dorsal groove and with darker radiating lines, the

sides darker than in the middle. Anterior eyes in a slightly procurved line, equal, the median separated by a little less than the diameter and closer to the lateral. Posterior eyes in a very slightly procurved line, equal, the median nearer to each other than to the lateral.

Clypeus nearly three times as wide as the diameter of an anterior lateral eye.

Sternum dusky over dull yellow. Labium dusky yellow margined with reddish brown. Endites and coxa dirty white darker on the sides. Legs dull yellowish marked with black as follows: femora of first two pairs with broad longitudinal stripes in front and behind, the third and fourth with spots at base. Palpi dusky. Chelicerae dull yellow ornamented with a black U-shaped mark in front.

Abdomen hard and shining above, very dark brown with a yellowish band across in front and another near the middle and with two indistinct spots behind the latter. Underside of abdomen light in the middle, darker in front of the epigastric furrow and a dark spot in front of the spinnerets.

Femur of palpus provided near the base below with rounded hooked knob bearing a few hairs; tibia armed on the outside with a long, strong, tapering, process; the ventral branch much shorter than in *P. pugnatus*.

Female. Length, 2.6 mm. Cephalothorax much as in the male but a little lighter. The dark stripes on the femora of the legs not so strongly developed as in the male, in one specimen from McLean, N. Y., almost lacking. Abdomen greenish gray marked with a pair of oval spots in front; a broad transverse band, yellowish white. Epigynum with the receptacles large and less than the diameter apart.

North Carolina: Blowing Rock, Oct. 10, 1923, 1♂.

Virginia: Blue Ridge near Roanoke, Oct. 7, 1923, 1♀.

Missouri: Mansfield, Oct. 1905, 1♀.

All collected by sifting decaying leaves. Banks' specimens were from Long Island, N. Y.

Phrurolithus umbratilis n. sp. Figs. 41–43

Male. Length, 2.1 mm. Cephalothorax with a brownish yellow area on the posterior part of the head and including the median furrow, the rest of the carapace brown, reticulated with black, margin black. Clypeus and the area including the anterior eyes black, the posterior lateral eyes surrounded by the dark color of the sides, the posterior median eyes in the median light area.

Anterior eyes in a procurved line, the median slightly smaller than

the lateral, separated from each other by less than the diameter and almost touching the lateral. Posterior eyes in a straight line, the median larger than the lateral, angulate, separated from each other by less than radius and from the lateral by the radius. Clypeus as wide as the diameter of an anterior lateral eye.

Sternum yellow with a broad median black stripe. Labium reddish brown at base, yellowish at tip. Endites brownish yellow at base, yellowish on inner margin, black laterally and distally. Coxae brownish yellow. Chelicerae brownish yellow, marked on the front with a distinct black U-shaped mark. Inside the mark there are a few variable black lines. Legs yellowish marked with black as follows: first leg—all of femur except narrow stripe above and a little broader stripe below; a narrow ring at tip of patella; a broader ring just beyond the middle of the tibia; an incomplete ring at base of metatarsus and a complete one near the middle; second leg—the same but the femur has a wider light stripe above; third and fourth legs—incomplete rings at base and near tip of femur; a broad ring beyond the middle of tibia; a ring at base and middle of metatarsus; an indistinct ring at base of tarsus of fourth leg only.

Abdomen covered above with a hard shining shield, dark brown with very indistinct chevrons on the hind half; sides with broken black lines; underside yellowish in ground color, black around the spinnerets, a pair of black spots in front of the spinnerets and with a black band back of the epigastric furrow sometimes broken into spots.

Femur or palpus swollen below and armed beyond the middle with a few stiff hairs, tibia armed with a stout curved process arising from near the base. This process is of the general form of that of *P. palustris* but is broader and blunter at tip (fig. 41).

Female. Length, 2.3 mm. Lighter in color with a more distinct pattern than in the male. Cephalothorax yellowish in ground color, narrowly margined, with a light irregular submarginal stripe and a broader dark band running from the posterior eyes back around the posterior declivity where it unites with the band from the opposite side; sometimes narrowly interrupted behind. Eye area dark with a small light area between the median eyes; the posterior median eyes narrowly ringed with black but included in the light central area. Clypeus dark. Chelicerae marked much as in the male. Sternum with the median longitudinal dark stripe distinct but not as broad as in the male. Labium, endites and coxae pale uniform yellowish. Legs marked with black as in the male but the markings not so distinct. Palpi yellowish not ringed with black.

Abdomen yellowish in ground color, with a black basal band from which there extends backwards three (sometimes five) short stripes. On the posterior half there are four distinct chevron marks which are extended diagonally on the sides. Underside of abdomen with same general pattern as in male but less distinct. Epigynum of the same general type as *P. palustris*. The receptacles less than the diameter apart (fig. 43).

Holotype male, allotype female, and 2♂ and 2♀ paratypes.

Georgia: Billy's Island, Okefinokee Swamp, June, 1912. Collected by sifting decaying leaves in heavy woods close to the edge of the swamp.

Family AGELENIDAE

Genus AGELENA Walckenaer

Agelena naevia Walckenaer

North Carolina: Oteen, Oct. 15, 1923, 1♂ and 2♀; Bridgewater, Oct. 14, 1923, 1♀.

Virginia: Alberta, Oct. 27, 1923, 1♀.

Alabama: Gallant, June 1911, 1♀; Three Island Shoals, Coosa River, Talladaga Co., Nov. 10, 1911, 1♂ and 3♀; Epes, Jan. 10, 1913, 1♀, young, Smith, coll.; Barbour Co., 1915, 1♀, Burke, coll.

Genus CICURINA Menge

Cicurina arcuata Keyserling

North Carolina: Oteen, Oct. 15, 1923, 4♂ and 1♀; Blowing Rock, Oct. 10, 1923, 1♂ and 1♀; Mt. Pisgah, Oct. 19, 1923, 5♂ and 5♀; Montreat, Oct. 16, 1923, 2♂; Grandfather Mt., Oct. 12, 1923, 1♂ and 1♀.

Virginia: Summit of Blue Ridge near Roanoke, Oct. 7, 1923, 1♂ and 1♀.

Alabama: Silas, Feb. 19, 1912, 2♀, Smith, coll.

Cicurina breviaria n. sp. Figs. 44–45

Male. Length, 4 mm. Cephalothorax pale yellowish tinged with dusky, median furrow nearly black, very broad and convex, with the sides rounded in front, not constricted as in *C. brevis*.

Anterior eyes in a slightly procurved line, the median much smaller than the lateral, separated by less than the radius and almost touching the lateral. Posterior eyes in a very slightly procurved line, the median

a little smaller than the lateral, separated from each other by a little less than the diameter and from the lateral by about one-half the diameter. Sternum pale yellowish, distinctly suffused with dusky, darker towards the sides, nearly as broad as long and with the anterior angles more nearly square than in *C. brevis*; clothed with numerous black hairs. Labium, endites and coxae same color as the sternum but smoother. Chelicerae dusky yellowish. Legs and palpi pale yellowish, distal segments slightly darker.

Abdomen grayish white with a short median basal mark, and back of this five pairs of small spots, the last three coalescent. The sides marked with broad diagonal rows of spots. The darker markings dusky with a decided greenish tinge. Underside of the abdomen dirty white, greenish gray in front of spinnerets and along the epigastric furrow; in front of the latter paler.

Tibia of the palpus armed on the outer, lower, distal angle with a rounded process larger and stronger than in *brevis*. The distal apophysis broad and flat, deeply emarginate at end, tips rounded. In *brevis* the emargination is on the outer side, not at the tip. Embolus relatively much shorter than in *brevis* (figs. 44–45).

Holotype male.

North Carolina: Grandfather Mt., Oct. 12, 1923. Collected by sifting leaves.

Cicurina brevis Emerton

North Carolina: Summit Mt. Mitchell, Oct. 22, 1923, 1 ♀; Blowing Rock, Oct. 10, 1923, 3 ♂ and 2 ♀; Grandfather Mt., Oct. 12, 1923, 3 ♀.

Virginia: Alum Springs, Oct. 5, 1923, 1 ♂.

Cicurina cavealis n. sp.

Female. Length, 7 mm. Cephalothorax reddish brown lighter in front of the median furrow, strongly convex, the sides slightly constricted toward the front.

Anterior eyes in a slightly procurved line, equidistant, the median smaller than the lateral, separated by about the radius. Posterior eyes in a slightly procurved line, equidistant, the median very slightly smaller than the lateral, separated by a little more than the diameter. Sternum, labium, endites and coxae yellowish tinged with reddish. Sternum sparsely clothed with long black hairs thicker towards the margin. Chelicerae reddish brown.

Legs and palpi reddish brown, lighter than the cephalothorax.

Abdomen yellowish gray marked with numerous irregular dark patches with an indication of a chevron pattern on the hinder half; underside dusky yellowish, lighter in front of spinnerets and in front of epigastric furrow.

Epigynum resembles that of *C. arcuata*. There is a transverse oval opening near the hind margin and the ducts show distinctly through the integument. The lateral loops of the ducts do not extend so far forward as in that species (fig. 46).

Holotype female.

Missouri: Rochport Cave, Dec. 30, 1904, 3 ♀.

In pocket-like webs on the piles of bat excrement. When disturbed they sought shelter under the stones at the edge of which the webs were placed.

These specimens were erroneously reported by Crosby as *Cicurina brevis* Emerton (Can. Ent. **37**: 367. 1905).

Cicurina ludoviciana Simon

Louisiana: Chastine, Feb. 25, Mar. 5, Apr. 18, 1915, 5 ♀, K. P. Schmidt, coll. Under ties.

Genus **COELOTES** Blackwall

Coelotes bimucronatus Simon. Figs. 47–48

Male. Length, 11.5 mm. Cephalothorax reddish, darker towards the front of the head and with dull radiating markings; a paler marginal band; viewed from above evenly rounded on the sides with the sides of the head parallel. Front of head bluntly rounded. Cephalothorax viewed from the side abruptly ascending behind to the cervical groove, flattened on top and gently rounded over to the eyes. Clypeus almost straight and slightly retreating. The eyes occupy only about half the width of the head. Posterior eyes in a slightly recurved line, equal, the median separated by the radius and from the lateral by one and one-half times the diameter. Anterior eyes in a very slightly recurved line, the median much smaller than the lateral, separated by a little less than the diameter and a little closer to the lateral. Median ocular area slightly longer than wide and a little wider behind than in front. Clypeus three times as wide as the diameter of an anterior median eye.

Sternum reddish orange, slightly darker at sides, longer than broad, oval, broadly rounded, truncate in front, pointed behind, clothed with scattered stiff black hairs. Labium and endites reddish, lighter distally.

Chelicerae dark reddish brown, strongly swollen basally in front, clothed with stiff dark hairs. Lower margin of the furrow of the chelicera armed with two short, blunt, rather widely separated teeth near the tip of the claw; upper margin armed with three teeth near the tip of the claw, the middle one the largest. Legs and palpi colored like the cephalothorax but lighter. Femora of first and second legs swollen above.

Abdomen above brownish with lighter, yellowish chevrons on the hinder half, broken oblique lines on the sides, other markings obscured.

Femur of palpus rather stout, gently curved mesally, armed dorsally on the distal half with three stout spines, the basal one the longest. Patella short, gradually widened distally, the lateral angle produced into a short round-pointed forward directed apophysis. Tibia as long as the patella but narrower; dorsally and mesally, the apical margin is thickened; venter laterally provided with a strong, curved, longitudinal ridge; armed dorso-mesally with three long spines. The tarsus is long, acuminate, and armed at the base, dorso-mesally, with two blunt processes (fig. 47). At the base, on the outer side, there is a broad groove, bounded above by a distinct curved ridge. The embolus arises near the base of the bulb and extends along the edge of the cymbium and behind the tip of the bulb (fig. 48).

Redescribed from 1♂ from the Forks of the Warrior River, Walker County, Alabama, Oct. 2, 1912, H. H. Smith, coll. Simon's type came from North Carolina.

Coelotes calcaratus Keyserling

North Carolina: Blowing Rock, Oct. 10, 1923, 3♂ and 2♀; Grandfather Mt., Oct. 12, 1923, 3♂ and 2♀; Montreat, Oct. 16, 1923, 2♀; Stony Mt., Hendersonville, Oct. 18, 1923, 1♀.

Pennsylvania: Lawrenceville, Oct. 2, 1923, 1♀.

Coelotes hybridus Emerton. Fig. 49

Banks has suggested that *C. altilis* is the female of this species. An examination of a series of females and males convinces us that the supposition is correct.

Female. Length, 7 to 12 mm., extremes of six specimens. Cephalothorax yellowish with radiating lines of greenish gray. Anterior eyes in a straight row, the median smaller than the lateral. Posterior eyes in a very slightly procurved line, equal, the median separated by a little less than the diameter and a little farther from the lateral.

Sternum brownish yellow, labium and endites darker; coxae lighter, sparsely clothed with long black hairs. Chelicerae reddish brown; lateral condyle reddish yellow. Legs and palpi dusky yellowish. Femora and tibiae of legs with darker bands near base and tip; patellae and metatarsi indistinctly annulate.

Abdomen dirty white in ground color with a greenish gray pattern. Anterior third distinctly darker. The pattern in general a coarse reticulation; on the posterior two-thirds forming five or six chevron marks with lines extending diagonally along the sides. Underside of abdomen irregularly spotted with a pair of broken lines from the epigynum to the spinnerets, lacking in some specimens.

Epigynum of the same general type as in *C. calcaratus* but posteriorly there is on each side a broad plate with rounded external margins; the median finger-like process is broader, shorter and less deeply notched at the tip. It is narrower at the base than in the middle (fig. 49).

North Carolina: Mt. Pisgah, Oct. 19, 1923, 4 ♀; Minehole Gap, Buncombe Co., Oct. 17, 1923, 1 ♀; Oteen, Oct. 15, 1923, 1 ♀; Grandfather Mt., Oct. 12, 1923, 1 ♂.

New York: McLean Bogs, Apr. 23, 1924, 1 ♀, and one immature ♀. Sifting.

Compared with a specimen of *C. altilis* Banks from Ithaca, N. Y., determined by Banks. In the Cornell University collection there is a female with the note that it was found in a silk-lined cavity with its young under a stone. Another specimen with young was taken May 21.

Coelotes plumarius n. sp. Fig. 50

Female. Length, 7 mm. Cephalothorax white, dusted with grayish, lighter on the head. Anterior eyes in a straight line, the median a little smaller than the lateral and separated from each other by the diameter and a little closer to the lateral. Posterior eyes in a slightly procurved line, equal, the median separated by about the diameter and a little farther from the lateral. All the eyes white, each surrounded by a black ring. Clypeus $1\frac{1}{4}$ times as wide as the diameter of an anterior lateral eye.

Sternum white tinged with dusky along the sides. Labium, endites and coxae white, armed sparsely with long black hairs. Sternum armed with similar hairs, thicker on the sides; in front armed with two long spines. Legs and palpi white. Chelicerae white, tinged with yellowish distally; lower margin of furrow armed with three evenly spaced teeth; claw white.

Abdomen dirty white, light in front and marked with gray chevrons behind and irregular spots on the sides. Underside of abdomen with two broad parallel white stripes, the median area occupied by a broad interrupted, gray stripe. Spinnerets white. The terminal segment of the hind spinnerets about two-thirds as long as the basal segment.

Whole body, legs and palpi clothed with fine appressed plumose hairs, the branches very long and slender.

Epigynum posteriorly with a transverse plate enlarged laterally (fig. 50).

Holotype female. Rosenberg Cave, on the bank of the Shenandoah River, Quicksburg, Va., Oct. 5, 1923. Taken in a small dark chamber near the entrance.

Genus CORAS Simon

Coras medicinalis Hentz

North Carolina: Oteen, Oct. 15, 1923, 1 ♀.

Tennessee: Knoxville, Nov. 1918, 1 ♂ and 1 ♀, Cartwright, coll.

Mississippi: Agricultural College, Oct. 1916, 4 ♂ and 2 ♀, Bailey, coll.

Alabama: Point Clear, Feb. 14, 1912, 1 ♀, Holt, Dec. 25, 1912, 1 ♀; Foley, Jan. 25, 1912, 1 ♀; Silas, Feb. 19, 1912, 2 ♀; University, May, 1 ♀; Mobile, Feb. 16, 1912, 1 ♂. Smith, coll.

Genus CRYPHOECA Thorell

Cryphoeca montana Emerton

North Carolina: Grandfather Mt., Oct. 12, 1923, 1 ♀.

Genus CYBAEUS L. Koch

Cybaeus montavencis n. sp. Figs. 51–53

Male. Length, 5.5 mm. Cephalothorax light yellowish, dusky on the sides, distinctly marked with dark gray as follows: a line back of each posterior lateral eye, a V-shaped mark in front of the median furrow, three irregular spots on each side of the thorax.

Anterior eyes in a very slightly procurved line, the median smaller than the lateral, separated by less than the diameter and a little nearer the lateral. Posterior eyes in a straight line, equal and equidistant, separated by a little less than the diameter.

Sternum pale straw-color in ground color, heavily shaded with

greenish gray with a pale median stripe in front; sparsely clothed with long black hairs. Labium and endites darker in ground color, not shaded with gray. Coxae same as sternum in ground color, gray confined to distal part. Chelicerae light reddish brown. Legs very light yellowish, almost white. Distinctly marked with broad but incomplete annulations of grayish green; four each on the femur and tibia. Femur and patella of palpus light yellowish tinged with dusky; tibia and tarsus darker.

Abdomen almost white in ground color marked with greenish gray as follows: a median basal lanceolate mark.followed by several irregular chevron marks continued laterally as oblique bands. Underside of abdomen with a yellowish ground color in a broad stripe, marked with two broad irregular gray stripes from the epigastric furrow to the spinnerets. Colulus broader than long, rounded behind.

Patella of palpus armed at the tip above with a small triangular tooth projecting forward and armed ventro-mesally with a short wide scoop-shaped process. Tibia straight on the inner side, the outer deeply excavated with a transverse groove in which there are two large teeth, the lower one larger and blunter (fig. 52). The outer distal angle produced into a long strong pointed apophysis. Embolus short and thick, directed towards the base of the tarsus, the tip resting on a short, broad process which is evidently the conductor (fig. 51).

Female. Length, 5.5 mm. Similar to the male but the markings and annulations on the legs more distinct. Lower margin of the furrow of the chelicerae armed with 8 or 9 small teeth. Epigynum provided with a narrow slit slightly widened anteriorly (fig. 53).

Holotype male. Grandfather Mt., N. C., Oct. 12, 1923. Allotype female, same place and date.

North Carolina: Blowing Rock, Oct. 10, 1923, 3 ♀; Mt. Pisgah, Oct. 19, 1923, 1 ♀; Minehole Gap, Buncombe Co., Oct. 17, 1923, 2 ♀.

Alabama: Forks of Warrior River, Walker Co., Oct. 20, 1912, 3 ♂, Smith, coll.

Cybaeus patritus n. sp. Figs. 54–55

Male. Length, 7 mm. Thorax grayish yellow, with distinct radiating lines; head brownish with darker reticulations. Anterior eyes in a straight line, equidistant, the median smaller than the lateral and separated by less than the diameter.

Sternum, labium and endites yellowish brown, sparsely clothed with black hairs. Coxae lighter than sternum. Chelicerae dark reddish

brown; lower margin of the furrow armed with 7 or 8 small blunt teeth. Legs grayish yellow with a tinge of green, terminal segments reddish. Palpi lighter. Abdomen dark gray, nearly black with a median basal lanceolate light mark and three pairs of indistinct light bars. Underside of abdomen pale yellowish in front of epigastric furrow; back of the furrow dark gray.

Patella of palpus armed at the tip on the ventro-lateral side with a blunt process bearing on the end a patch of short stout black spines reduced to denticles. (In *C. silicis* the process is shorter and the black spines are longer, sharper and slightly curved and appear more like true spines.) Tibia about as long as patella. (In *silicis* the tibia is much longer than the patella.) Tibia armed at tip ventro-laterally with a thin leaf-like process more strongly developed than in *silicis*. The conductor is shorter, wider, and not so strongly curved as in *silicis* (fig. 54).

Female. Length, 10 mm. Cephalothorax and legs similar to male in coloration. Abdomen dark gray sprinkled with numerous fine light spots and marked down the back with a series of divergent short light lines. Underside of body colored as in male.

Epigynum similar to that of *silicis* but the four rounded sacs which show through the integument are not in a transverse row (fig. 55).

Holotype male, allotype female. Both from Grandfather Mt., N. C., Oct. 12, 1923; Mt. Pisgah, N. C., Oct. 19, 1923, 1 ♀.

Compared with a pair of specimens of *silicis* from Rockbridge, Ohio, determined by Barrows.

Cybaeus silicis Barrows

North Carolina: Montreat, Oct. 16, 1923, 1 ♂.

Genus HAHNIA C. Koch

KEY TO THE COMMON SPECIES OF HAHNIA

A. Opening of spiracles midway between epigynum and spinnerets ..... *brunnea* Emerton
AA. Opening of spiracles nearer epigynum than spinnerets ..... *agilis* Keys.
AAA. Opening of spiracles nearer spinnerets than epigynum
B. Cephalothorax and legs, pale yellow ..... *flaviceps* Emerton
BB. Cephalothorax with dark radiating markings ..... *cinerea* Emerton

Hahnia agilis Keyserling

North Carolina: Oteen, Oct. 15, 1923, 2 ♀; Mt. Pisgah, Oct. 19, 1923, 1 ♂; Walnut Creek, Raleigh, Oct. 26, 1923, 1 ♂; Bridgewater, Oct. 14, 1923, 1 ♂.

Hahnia cinerea Emerton

North Carolina: Walnut Creek, Raleigh, Oct. 26, 1923, 2 ♀.

Family PISAURIDAE

Genus **DOLOMEDES** Latreille

Dolomedes okefinokensis Bishop

North Carolina: Raleigh, Walnut Creek, Oct. 26, 1923, 1 ♀, young.

Dolomedes scriptus Hentz

North Carolina: Swannanoah, Oct. 16, 1923, 1 ♀, young.
Missouri: Columbia, Sept. 1903, 1 ♀, Hayhurst, coll.
Kentucky: Anderson Co., Kentucky River, June 20, 1919, 1 ♀, Funkhouser, coll.

Dolomedes tenebrosus Hentz

North Carolina: Oteen, Oct. 15, 1923, ♀, young.
Virginia: Buchanan, Oct. 6, 1923, ♀, young.

Dolomedes triton sexpunctatus Hentz

North Carolina: Raleigh, Walnut Creek, Oct. 26, 1923, ♀, young; Nov. 12, 1923; 1 ♂, C. S. Brimley, coll.
Louisiana: Jennings, 1 ♀.

Dolomedes urinator Hentz

North Carolina: Oteen, Oct. 15, 1923, ♀, young.

Dolomedes vittatus Walckenaer

North Carolina: Oteen, Oct. 15, 1923, 1 ♂.

Genus **PISAURINA** Simon

Pisaurina mira Walckenaer

North Carolina: Madison, Oct. 6, 1923, 1 young.
Pennsylvania: Lawrenceville, Oct. 2, 1923, 1 ♀, young.

Family LYCOSIDAE

Genus ALLOCOSA Banks

Allocosa rugosa Keyserling

District of Columbia: June, 1 ♂, Fox, coll.

Genus GEOLYCOSA Montgomery

Geolycosa arenicola Scudder

North Carolina: Oteen, Oct. 16, 1923, 1 ♂, young.
District of Columbia: Apr. 1888, 2 ♀ im., Fox, coll.
Tennessee: Knoxville, Nov. 1918, 1 ♀, Cartwright, coll.

Geolycosa fatifera Hentz

Oklahoma: Kingfisher, 1 ♀; Ponca City, Nov. 2, 1907, 1 ♂, Hayhurst, coll.; Goltry, Oct. 13, 1907, 1 ♂, Hayhurst, coll.

Genus LYCOSA Latreille

Lycosa acompa Chamberlin

Georgia: Billy's Island, Okefinokee Swamp, June 1912, 3 ♀.

Lycosa apicata Banks

Mississippi: Agricultural College, Oct. 1916, 2 ♀, J. C. Bradley, coll.

Lycosa antelucana Montgomery

Mississippi: Agricultural College, Oct. 1916, 2 ♀, Bailey, coll., Chamberlin det.

Lycosa aspersa Hentz

Alabama: Three Island Shoals, Coosa River, Talladaga Co., Nov. 14, 1911, 1 ♀, Smith, coll.
District of Columbia: Oct., 1 ♀, Fox, coll.
Mississippi: Agricultural College, Mar. 23, 1903, 1 ♀, Comstock, coll.; Summer 1919, 1 ♀, Bailey, coll.
Missouri: Columbia, Oct. 10, 1903, 4 ♀, Hayhurst, coll.

Lycosa avara Keyserling

Maryland: Bayshore Park, Baltimore, Dec. 29, 1918, 1 ♂.
Virginia: Winchester, Oct. 5, 1923, 1 ♀; South Hill, Oct. 27, 1923, 1 ♀.

North Carolina: Oteen, Oct. 15, 1923, 1♂, and 1♀; Mt. Pisgah, Oct. 19, 1923, 3000 ft., 1♀.

Alabama: McGus Station, Montgomery Co., Dec. 24, 1915, 1♀; Silas, Feb. 11, 1912, 1♀; Cohor, Apr. 11, 1912, 1♀; Tuscaloosa, Apr. 6, 1912, 1♀; Foley, Jan. 25, 1912, 1♀; Magnolia Spring, Baldwin Co., Feb. 5, 1912, 2♀, Smith, coll.

Mississippi: Ocean Springs, Jan. 1905, 1♂ and 2♀, Comstock, coll.

Louisiana: Chastine, May 16, 1915, 1♀, Schmidt, coll.

Tennessee: Knoxville, 1♂, Cartwright, coll.

Missouri: Mansfield, Oct. 1905, 1♀; Columbia, Sept.-Oct., 1903, 1♂ and 5♀; May, 1♂ and 1♀.

Lycosa avida Walckenaer

District of Columbia: 1♂, Fox, coll.

Georgia: Billy's Island, Okefinokee Swamp, June 1912, 2♀.

Mississippi: Agricultural College, Mar. 25, 1903, 1♂, Comstock, coll.

Louisiana: Baton Rouge, 1♂.

Kentucky: Breathitt Co., June 20, 1923, 1♂ and 3♀, Funkhouser, coll.

Missouri: Springfield, July 19, 1912, 1♀. Knight, coll.; Columbia, 4♀.

Lycosa carolinensis Walckenaer

North Carolina: Chapel Hill, Feb. 27, 1886, 1♀, Atkinson, coll.

Georgia: Billy's Island, Okefinokee Swamp, June 1912, 15♀; July 28, 1♀, Apr. 27, 1921, 1♀, Wright and Harper, coll., May 5, 1921, 1♀, Wright, coll.; Chesser Island, July 2, 1922, 2♀, Harper, coll.; Charlton Co., June 17, 1922, 1♀, Wright, coll.; Spring Creek, Decatur Co., July 1912, 1♀.

Mississippi: Agricultural College, 1♀; Apr. 8, 1917, 1♀, Kizer, coll.; Oct. 1916, 1♂ and 1♀, Bailey, coll.; Oxford, July 1905, 1♀, Fulton, coll.

Louisiana: Chastine, Mar. 5, 1915, 1♂ and 3♀, Schmidt, coll.

Texas: Austin, Mar. 12, 1903, 1♀, Comstock, coll.

Tennessee: Knoxville, Oct. 1918, 1♀, Cartwright, coll.

Kentucky: Hart Co., Aug. 7, 1921, 1♂; Breathitt Co., June 20, 1923, 1♂ and 3♀, Funkhouser, coll.

Missouri: Columbia, 2♀.

Lycosa cinerea Fabricius

Georgia: Billy's Island, Okefinokee Swamp, June 1912, 2♀; Bainbridge, Sept. 1911, 1♂.

Missouri: Columbia, Oct. 1♂ and 1♀.

Lycosa frondicola Emerton

Pennsylvania: Gettysburg, Oct. 3, 1923, 1♀.

Lycosa gulosa Walckenaer

Maryland: Cabin John, Dec. 3, 1918, 1♀.

Virginia: Nottoway River, Oct. 27, 1923, 1♀, Pamunkey River, Oct. 27, 1923, 2♀; Richmond, Oct. 28, 1923, 1♂; Strassburg, Oct. 4, 1923, 1♀; Timberville, Mar. 15, 1917, 1♀.

District of Columbia: Oct. 1♂ and 3♀; Feb., 1♂, Apr. 1888, 1♂ and 1♀, Fox, coll.; July 1, 1912, 1♀.

North Carolina: Raleigh, Nov. 12, 1923, 1♂, C. S. Brimley, coll.; Mt. Pisgah, Oct. 19, 1923, 1♀, 3000 ft.; Walnut Creek, Raleigh, Oct. 26, 1923, 2♀; Minehole Gap, Buncombe Co., Oct. 17, 1923, 1♀.

Alabama: Point Clear, Feb. 14, 1912, 1♀; Three Island Shoals, Coosa River, Talladaga Co., Nov. 14, 1911, 2♂ and 1♀, Smith, coll.

Mississippi: Agricultural College, Oct. 1916, 1♂ and 1♀, Bailey, coll.; Ocean Springs, Jan. 1905, 2♀, Comstock, coll.

Kentucky: Woodford Co., along Kentucky River, Sept. 16, 1920, 1♂, Funkhouser, coll.

Tennessee: Knoxville, Oct. 1918, 1♀, Cartwright, coll.

Missouri: Columbia, Sept.–Oct. 1903, 3♂ and 8♀; Nov. 4, 1903, 2♀, Hayhurst, coll.; Nov. 1904, 1♀.

Lycosa helluo Walckenaer

District of Columbia: Aug., 1♀, Fox, coll.

North Carolina: Raleigh, Walnut Creek, Oct. 26, 1923, 1♂ and 2♀ young.

Georgia: Billy's Island, Okefinokee Swamp, June 1912, 4♀.

Alabama: Gallant, June 1911, 2♂ and 3♀; University, June 15, 1913, 1♂; Elrod, July 8, 1911, 1♀, Smith, coll.

Mississippi: Gulfport, June 9, 1920, 1♀, Benjamin, coll.; Agricultural College, Oct. 1916, 1♂ and 6♀; Summer 1915, 1♀, Bailey, coll.; Apr. 2 1917, 1♀, Few, coll.; Oct. 4, 1912, 1♀, Morrison, coll.

Louisiana: Chastine, May 18, 1915, 2♀, Schmidt, coll.

Texas: Austin, Mar. 12, 1903, 1 ♀, Comstock, coll.
Tennessee: Knoxville, Oct. 8, 1 ♀, Cartwright, coll.
Missouri: Columbia, Sept.–Oct., 1903, 2 ♀, Hayhurst, coll.

Lycosa lenta Hentz

North Carolina: Southern Pines, Aug. 15, 1902, 1 ♂.
Georgia: Atlanta, May 27, 1912, 1 ♀; Billy's Island, Okefinokee Swamp, May 1, 1921, 1 ♂ and 1 ♀, Wright and Harper, coll.
Florida: Miami, Feb. 1903, 1 ♀, Comstock, coll.
Alabama: Gallant, June 1911, 1 ♀; Foley, Jan. 25, 1912, 1 ♀; Livingston, Apr. 15, 1914, 2 ♀, Smith, coll.; Auburn, July 20, 1924, 1 ♀, Good, coll.
Mississippi: Agricultural College, Oct. 1916, 6 ♂ and 2 ♀, Bailey, coll.

Lycosa lenta baltimoriana Keyserling

North Carolina: Oteen, Oct. 15, 1923, 1 ♂.
Louisiana: Chastine, Mar. 1915, 1 ♂, Schmidt, coll.

Lycosa punctulata Hentz

District of Columbia: Oct., 1 ♂ and 1 ♀, Fox, coll.
North Carolina: Raleigh, Walnut Creek, Oct. 26, 1923, 1 ♀; Chapel Hill, Mar. 27, 1886, 1 ♀, Atkinson, coll.
Georgia: Billy's Island, Okefinokee Swamp, June, 1912, 1 ♀.
Mississippi: Agricultural College, Oct. 1916, 4 ♀, Bailey, coll.
Louisiana: New Orleans, Nov. 9, 1903, 1 ♀, Sherman, coll.; Tallulah, June 14, 1925, 1 ♀, Folsom, coll.; Chastine, Mar. 24, 1915, 5 ♀, Schmidt, coll.
Tennessee: Knoxville, Oct. 1918, 1 ♀, Cartwright, coll.
Missouri: Columbia, Sept.–Oct. 1903, 1 ♂ and 2 ♀, Hayhurst, coll.
Oklahoma: Newkirk, Oct. 8, 1907, 1 ♂, Hayhurst, coll.

Lycosa rabida Walckenaer

Georgia: Billy's Island, Okefinokee Swamp, June 1912, 1 ♀; Chesser Island, June 18, 1921, 1 ♀, Wright, coll.
Alabama: Elrod, July 9, 1911, im., Smith, coll.
Mississippi: Agricultural College, Aug. 2, 1920, 1 ♂ and 1 ♀, Benjamin, coll.; Oct. 1916, 6 ♀, Bailey, coll.; Mar. 1, 1907, 2 ♀, Harned, coll.
Louisiana: Baton Rouge, Mar. 23, 1903, 7 im., Comstock, coll.
Kentucky: Hart Co., Aug. 7, 1921, 1 ♂ and 1 ♀; Twila, 3000 ft.,

Aug. 14, 1919, Funkhouser, coll.; Valley View, Aug. 31, 1921, 2 ♀; Pine Mt., Bell Co., Aug. 12, 1919, 1 ♂. All collected by Funkhouser.

Missouri: Mountain Grove, Aug. 1905, 1 ♀.

Lycosa riparia Hentz

Virginia: Nottoway River, Oct. 27, 1923, 1 ♂, young; Pamunkey River, Oct. 27, 1923, 1 ♀; Jamestown, June 16, 1920, 1 ♀. Common along shady water courses.

North Carolina: Raleigh, Walnut Creek, Oct. 26, 1923, 1 ♂ and 1 ♀; Nov. 12, 1923, 1 ♀, C. S. Brimley, coll.; Oteen, Oct. 15, 1923, 1 ♀.

Florida: 2 ♀, Mrs. Treat, coll.

Alabama: Livingston, low woods, Tombigbee River, May 9, 1914, 2 ♀; University, June 15, 1913, 1 ♀; Keener, May 10, 1913, 1 ♀; Pratt's Ferry, June 1912, 1 ♀, Smith, coll.; Auburn, Sept. 1924, 1 ♀, Good, coll.

Mississippi: Agricultural College, Apr. 3, 1904, 1 ♀; Oct. 1916, 1 ♀; May 10, 1917, 1 ♀; Bailey, coll.

Louisiana: Chastine, Mar. 11, 1915, 4 ♀, Schmidt, coll.

Texas: 1 ♀.

Lycosa rubicunda Keyserling

District of Columbia: 1 ♀, Marx, coll.

Lycosa scutulata Hentz

Alabama: Pratt's Ferry, June 1912, 1 ♀, Smith, coll.; Auburn, Sept. 1924, 1 ♀, Good, coll.

Mississippi: Agricultural College, summer 1915, 1 ♀, Bailey, coll.

Missouri: Columbia, Oct. 7 ♀; Nov. 1904, 1 ♀.

Texas: 2 ♀.

Lycosa suprenans Chamberlin

Alabama: Tuscaloosa, Apr. 6, 1912, 1 ♀, Smith, coll.

Genus **PARDOSA** C. Koch

Pardosa emertoni Chamberlin

Pennsylvania: Liberty, Oct. 2, 1923, 2 ♀. Running in short grass in bush lot.

Pardosa milvina Hentz

North Carolina: Raleigh, Walnut Creek, Oct. 26, 1923, 1 ♀; Grandfather Mt., Oct. 12, 1923, 1 ♀.

Virginia: Rocky Mount, Oct. 8, 1923, 1 ♀; Pamunkey River, Oct. 27, 1923, 1 ♂.

Alabama: Holt, Mar. 25, 1912, 1 ♀; July 18, 1911, 2 ♀; Barbour Co., 1915, 1 ♀; University, June 15, 1913, 1 ♂, Smith, coll.

Genus **SCHIZOCOSA** Chamberlin

Schizocosa bilineata Emerton

Alabama: Cohor, Apr. 11, 1912, 1 ♀, Smith, coll.
Louisiana: Chastine, May 18, 1915, 1 ♀, Schmidt, coll.
Missouri: Columbia, 1 ♀.

Schizocosa crassipes Walckenaer

Alabama: Livingston, low ground, May 9, 1914, 2 ♀; University, June 15, 1913, 2 ♀; Cohor, Apr. 11, 1912, 2 ♂; Fort William Shoals, Shelby Co., June 27, 1914, 1 ♀; Elrod, July 9, 1911, 1 ♀, Smith, coll.

Schizocosa saltatrix Hentz

Alabama: Cohor, Apr. 11, 1912, 1 ♂, Smith, coll.

Genus **TRABEA** Simon

Trabea aurantiaca Emerton

Virginia: Anna River, Oct. 28, 1923, 2 ♀.
Missouri: Columbia. Several specimens.

EXPLANATION OF FIGURES

PLATE 20

Fig. 1. *Myrmekiaphila fluviatilis* Hentz. Eyes from in front.
Fig. 2. Same. Right front leg of male, lateral view.
Fig. 3. Same. Chelicera from in front.
Fig. 4. Same. Left palpus of male, lateral view.
Fig. 5. Same. Tarsus of left palpus of male, side view.
Fig. 6. Same. Tip of left palpus of male, anterio-lateral view.
Fig. 7. *Myrmekiaphila comstocki* n. sp. Left palpus of male, dorso-lateral view.
Fig. 8. Same. Tarsus of right palpus of male, lateral view.

PLATE 21

Fig. 9. *Amaurobius armipotens* n. sp. Right palpus of male, dorsal view.
Fig. 10. Same. Right palpus of male, ventral view.
Fig. 11. Same. Epigynum.
Fig. 12. *Amaurobius hoplites* n. sp. Right palpus of male, dorsal view.
Fig. 13. Same. Right palpus of male, ventral view.
Fig. 14. Same. Epigynum.
Fig. 15. *Amaurobius hoplomachus* n. sp. Right palpus of male, dorsal view.
Fig. 16. Same. Right palpus of male, ventral view.
Fig. 17. Same. Epigynum.

PLATE 22

Fig. 18. *Amaurobius tibialis* Emerton. Right palpus of male, dorsal view.
Fig. 19. Same. Right palpus of male, ventral view.
Fig. 20. Same. Epigynum.
Fig. 21. *Dipoena intrita* n. sp. Right palpus of male, ventral view.
Fig. 22. *Mysmena guttata* Banks. Right palpus of male, ventral view.
Fig. 23. *Paidisca marxi* Crosby. Right palpus of male, ventral view.
Fig. 24. Same. Epigynum.
Fig. 25. Same. Femur of first leg of male.
Fig. 26. Same. Abdomen of male, ventral view.
Fig. 27. Same. Tarsal claws of male.

PLATE 23

Fig. 28. *Theridion dimachaerum* n. sp. Right palpus of male, ventral view.
Fig. 29. *Theridion flavonotatum* Becker. Right palpus of male, ventral view.
Fig. 30. *Theridion imparatum* n. sp. Right palpus of male, ventral view.
Fig. 31. *Anahita punctulata* Hentz. Right palpus of male, ventral view.
Fig. 32. Same. Right palpus of male, lateral view.
Fig. 33. Same. Epigynum.

Fig. 34. *Castaneira amoena* C. Koch. Right palpus of male, ventral view.
Fig. 35. *Ctenus hybernalis* Hentz. Right palpus of male, ventral view.
Fig. 36. Same. Epigynum.

PLATE 24

Fig. 37. *Gayenna maculata* Banks. Right palpus of male, dorso-lateral view.
Fig. 38. Same. Right palpus of male, ventral view.
Fig. 39. *Phrurolithus paludivagus* n. sp. Right palpus of male, lateral view.
Fig. 40. Same. Epigynum.
Fig. 41. *Phrurolithus umbratilis* n. sp. Right palpus of male, dorsal view.
Fig. 42. Same. Right palpus of male, ventral view.
Fig. 43. Same. Epigynum.
Fig. 44. *Cicurina breviaria* n. sp. Right palpus of male, dorso-lateral view.
Fig. 45. Same. Right palpus of male, ventral view.
Fig. 46. *Cicurina cavealis* n. sp. Epigynum.

PLATE 25

Fig. 47. *Coelotes bimucronatus* Simon. Right palpus of male, mesal view.
Fig. 48. Same. Right palpus of male, ventral view.
Fig. 49. *Coelotes hybridus* Emerton. Epigynum.
Fig. 50. *Coelotes plumarius* n. sp. Epigynum.
Fig. 51. *Cybaeus montavencis* n. sp. Right palpus of male, ventral view.
Fig. 52. Same. Tibia of right palpus of male, dorsal view.
Fig. 53. Same. Epigynum.
Fig. 54. *Cybaeus patritus* n. sp. Right palpus of male, ventral view.
Fig. 55. Same. Epigynum.

PLATE 20

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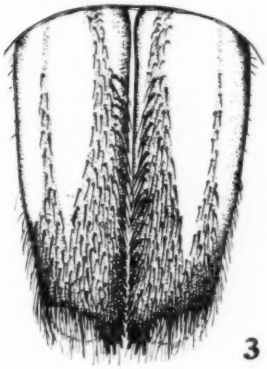

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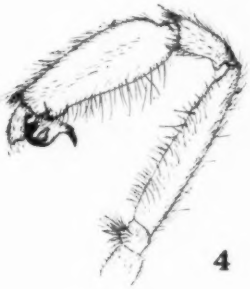

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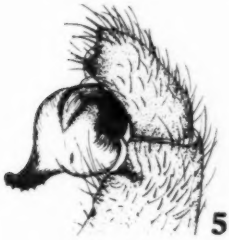

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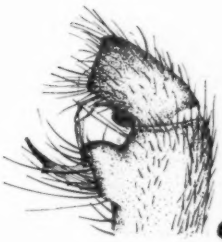

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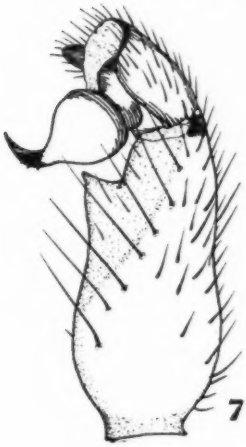

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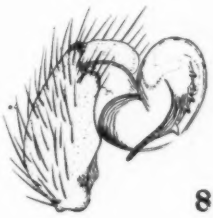

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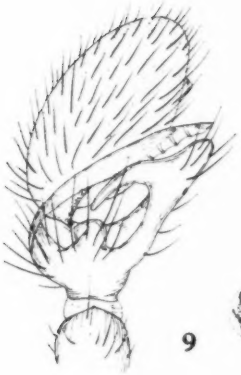

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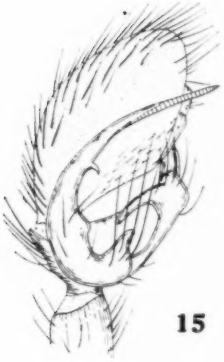

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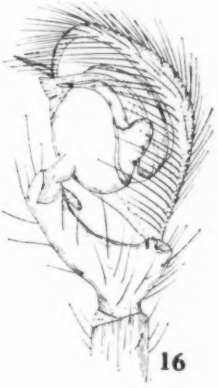

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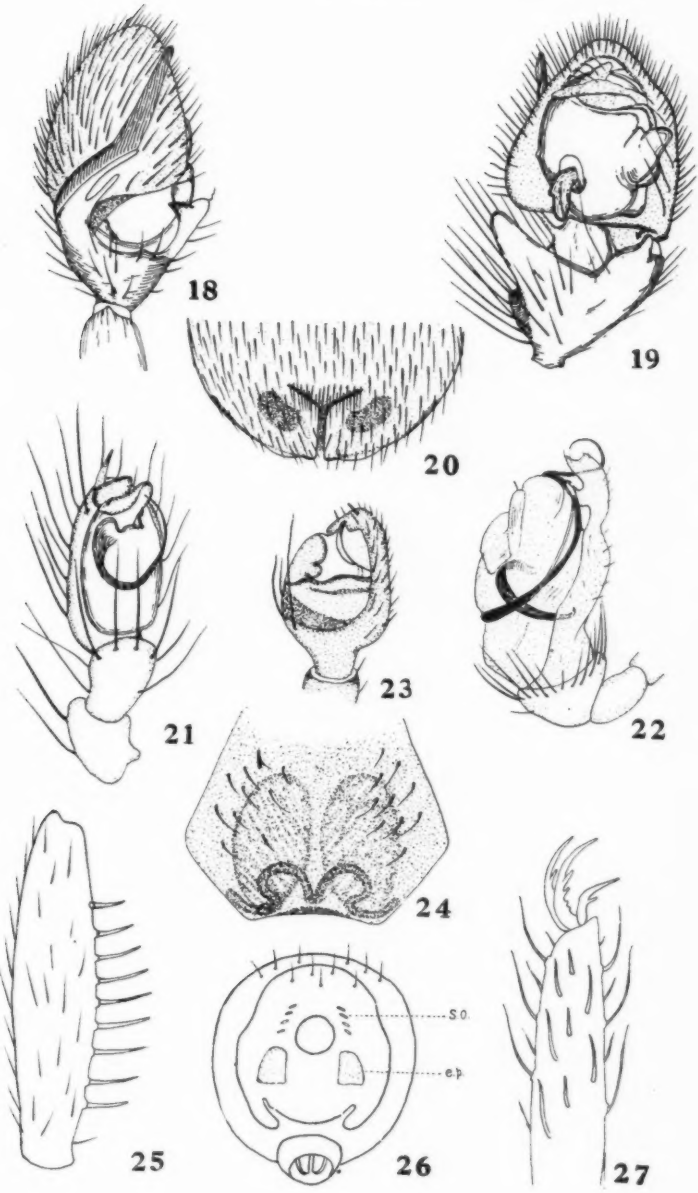

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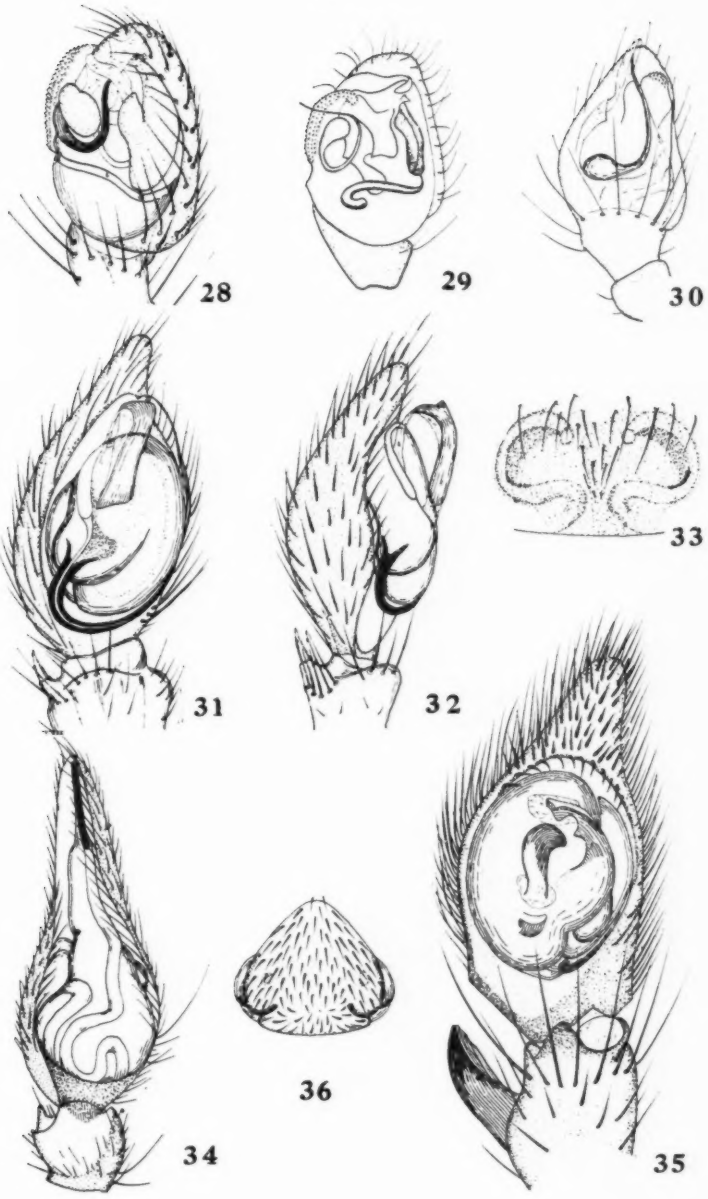

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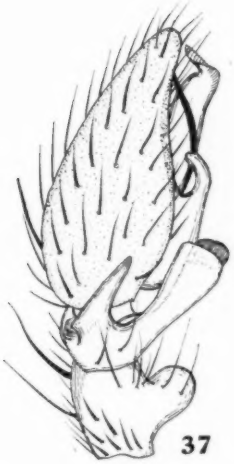

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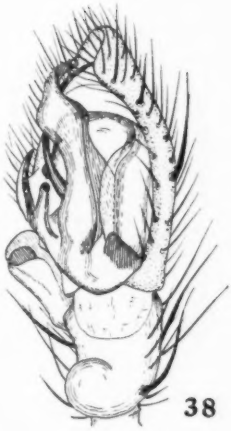

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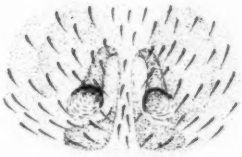

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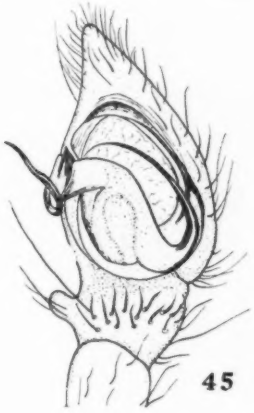

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PLATE 25

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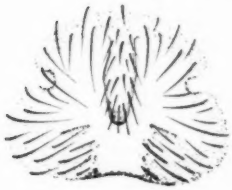

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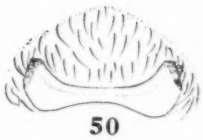

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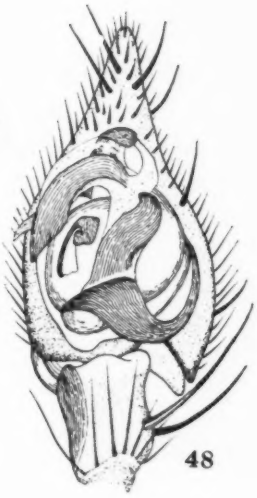

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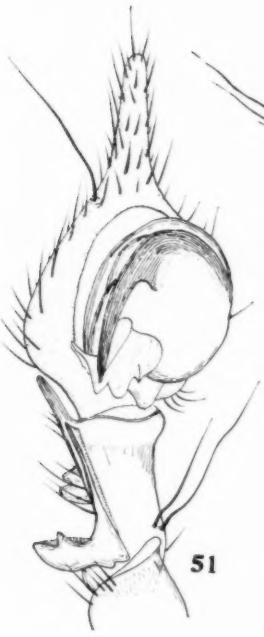

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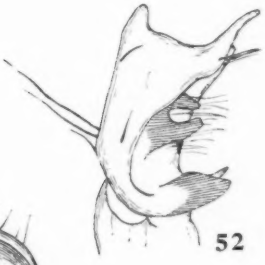

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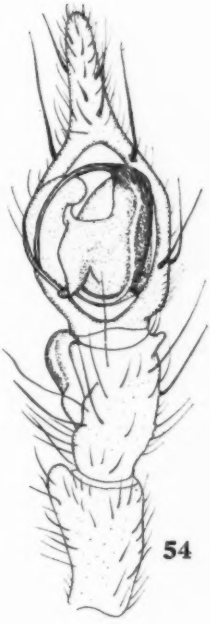

54

NOTES ON THE GENUS APHANOMYCES, WITH A DESCRIPTION OF A NEW SEMIPARASITIC SPECIES

By J. N. Couch

Plates 26–33

The genus *Aphanomyces* should be of particular interest to students of fungi and of parasitism in general because it shows in its species such a remarkable range in growth habits. This range extends from the nearly purely saprophytic species as *Aphanomyces laevis*, through the condition of obligate parasitism as found in *A. parasiticus* on species of *Achlya*, to the obligate parasitism of *Aphanomyces phycophilus* on conjugate algae. Quite recently Drechsler (Jones and Drechsler, '25) has described a new species of *Aphanomyces*, *A. euteiches*, which parasitizes the roots of peas but is culturable as a saprophyte.

In the present paper some general remarks on the growth habits of the members of the genus are given, together with notes on *A. phycophilus*, notes on a new form of *A. laevis*, and a description of a new species which shows a remarkable range in its growth habits. This work was done in the botanical laboratory of the University of North Carolina under the direction of Dr. W. C. Coker, to whom the writer is greatly indebted for criticism and advice. The writer also wishes to thank Miss Alma Holland for inking in plate 32 and part of plate 33.

The genus *Aphanomyces* as at present constituted can be divided into the following groups according to the saprophytic or parasitic habit of the species, as is shown in table I.

None of the species is an obligate saprophyte, as the three species, A. *laevis*, *A. scaber*, and *A. stellatus*, which are almost invariably saprophytic in their habit, have all been found growing parasitically on algae or within the threads of other water molds. Coker ('23) described a strain of *A. laevis* parasitizing desmids and diatoms, while the present writer has found *A. scaber* and *A. stellatus* growing within the living threads of species of *Achlya*. The new species herewith described may be cultured as a pure saprophyte or may be cultured as a parasite and saprophyte at the same time. Two of the species, *A. phycophilus* and

A. parasiticus, are apparently obligate parasites, and all efforts to culture them saprophytically have failed.

TABLE I

OBLIGATE SAPROPHYTES:
None
HEMI-SAPROPHYTES:
A. laevis (Rarely parasitizes diatoms and desmids; oogonia smooth, 18–33μ thick; with antheridia)
A form (With a few spiny oogonia and rarely with oogonia containing 2 eggs)
A. scaber (Rarely on *Achlya;* oogonia 15–24μ thick, wall uneven to tuberculate; antheridia absent in Chapel Hill form)
A. stellatus (Rarely on *Achlya;* oogonia 22–23μ thick, wall covered with blunt papillae; antheridia present on all oogonia)
A. exoparasiticus (Parasitizes all Phycomycetes tested; oogonia 25–40μ thick; egg 24–29μ thick)
A. euteiches Drechsler (Parasitizes the roots of peas; culturable as a saprophyte on corn meal agar, etc.; oogonia 25–35μ thick, inner surface of oogonial wall sinuous, eggs 18–25μ thick)
OBLIGATE PARASITES:
A. phycophilus (On conjugate algae; oogonia 40–50μ thick, spiny; egg 36μ thick)
A. parasiticus (On *Achlya;* oogonia 14–22μ thick; egg 12.8–21.7μ thick; threads running inside the host except in reproduction)

Aphanomyces phycophilus de Bary

Threads larger than in other species of the genus, 7.4–14μ thick; growing longitudinally through the cells of *Spirogyra* and developing numerous, considerably branched haustoria which intermingle with the chromatophores, causing their disorganization and collapse into irregular masses. Threads often extending outside the host. Asexual reproduction not observed. Oogonia formed in considerable abundance, usually extramatrical but rarely also formed within the host threads; borne on lateral stalks equal in length or slightly longer than the diameter of oogonia; oogonia 40–50μ in diameter counting the numerous, conspicuous, blunt spines which are 6–9.3μ long; wall becoming dark brown upon maturity. Egg single in the oogonium, 30–38μ thick. Antheridia of diclinous or androgynous origin, usually one on an oogonium.

This species can readily be distinguished from other members of the genus by its thicker threads, parasitic habits, and large bluntly spiny oogonia, and by the absence or extreme rarity of asexual reproduction.

This interesting parasite has heretofore been reported from Germany

by de Bary and from Michigan by Kauffman, and from Indiana by Weatherwax. Last spring (1924) in some algal material collected from near Georgetown, S. C., we found an abundant lot of the fungus parasitizing the threads of *Spirogyra;* this spring (1925) we collected it several times on *Spirogyra areolata* and an undetermined species of *Spirogyra*. Since de Bary, who first described the fungus, has made the only attempts to culture it, but was unable to induce the plant to grow, it seemed a matter of interest to make a rather exhaustive effort to culture the fungus on artificial media and especially on different kinds of nutrient agar.

Healthy threads of the fungus, some of which were extending out of the *Spirogyra* threads, were cut off, some with and others without parts of the *Spirogyra*, and were placed on corn- and oat-meal agar plates. Healthy threads of the fungus were also placed on bits of boiled corn grain, hemp seed, termite ants, mushroom grubs, etc. All efforts, however, to culture the fungus were unsuccessful.

As no one has ever observed with certainty any form of asexual reproduction in the plant, an effort was made to induce the formation of sporangia by transferring filaments of the *Spirogyra* containing numerous healthy threads of the parasite to fresh, pure water, a process which is usually successful in inducing the formation of sporangia in other species, but without any success in the case of the present plant.

Aphanomyces laevis, a form

Threads delicate, averaging about 6μ thick, straight or slightly sinuous, not rarely branched. Sporangia of the same thickness as the threads, very long. Spores clustering at the sporangial tip upon discharge, diplanetic, 8–11μ thick. Oogonia usually borne on much curled, racemose branches, but not rarely on short, straight branches; often in dense clusters with 20 or more oogonia in a cluster, varying from 18–48μ in diameter, most 29–35μ thick, spherical or slightly subspherical, wall smooth except in old cultures, and then the oogonial walls often appear spiny, due to the disappearance of part of the antheridial walls and the persistence of the other parts, often yellow in old cultures, apparently unpitted. Antheridia on all oogonia, one, two, or several, not rarely nearly covering the oogonium; antheridial tubes developed which apparently penetrate the egg. Eggs single in the oogonium, very rarely two may be present, not completely filling the oogonium, 14–35μ thick, most between 22–28μ thick, structure as in *A. laevis*. Recognized twice in over a hundred collections around Madison, Wisconsin, and then from Lake Mendota opposite stock pavilion, No. 31, July 1, 1923, and No. 48, July 20, 1923.

This plant differs from the form of *A. laevis* treated by Coker ('23) in the larger oogonia and eggs and the brown color of the former and also by the oogonia in this variety occasionally appearing spiny due to the disintegration of part of the antheridial wall. Very rarely oogonia may be observed with two eggs, a condition heretofore not reported in the genus. The oogonia in this form quite often show a tendency to form in dense clusters with often as many as twenty or more oogonia in a cluster. Such clusters can easily be recognized with the unaided eye and give the cultures a very distinctive appearance.

Petersen ('10) suggested that this species occurs in many varieties and this certainly seems to be the case. De Bary originally described the eggs as 27–33μ thick, and most of the eggs of Coker's plant described from Chapel Hill are 19–22μ thick. Coker ('23) has described also a variety parasitic on algae.

Aphanomyces exoparasiticus Coker and Couch n. sp.

Mycelium facultatively a semi-parasite on the threads of other Phycomycetes; also culturable as a pure saprophyte on corn meal agar seeds, and insects (mushroom grubs, ant larvae, etc.). Hyphae, when growing as a semi-parasite, twining about the threads of the host and rapidly destroying them; when growing as a saprophyte on vegetable or animal matter in water, much as in *A. laevis* or *stellatus*, but not so strongly developed; on corn meal agar the mycelium is abundantly developed forming rhizoid-like, lateral outgrowths much like those entwining the host threads when the plant is growing semi-parasitically. Sporangia formed in abundance on hemp seed, rather sparingly developed when growing as a semi-parasite in water, not developed in solid media; indistinguishable from those of *A. laevis* or *A. scaber*. Spores 8.1–11.1μ, averaging about 9.3μ thick, diplanetic. Sexual organs abundantly developed under most conditions, very numerous when growing saprophytically on corn meal agar, fairly abundant when growing semi-parasitically on other fungi in water, rarely or not at all developed when growing saprophytically on bits of hemp seed or corn grains in water. Oogonia usually borne on lateral stalks which are several times longer than the diameter of the oogonia; 28–40μ thick, most 33–37μ thick, not counting the long, usually sharp pointed, rarely short and blunt, and very conspicuous spines which vary from 5.5–14μ long; spines 10–20 to an oogonium; oogonial wall 1.8–2.5μ thick. Eggs single in the oogonium, nearly filling the latter, 24–30μ thick, spherical, rather thick-walled, 2–2.5μ thick, with a centric or subcentric, large oil drop surrounded by granular protoplasm. Antheridial branches diclinous, arising usually from a thread near the base of the oogonial stalk and twining around the latter; antheridia either short and tuber-like or often long and wrapping around the oogonia, coming in contact with

the oogonia very early, completely emptying their contents; the empty antheridia thick-walled and long persistent.

This peculiar plant was first observed growing as a semi-parasite on an unidentified species of *Pythium*, collected by Mr. J. V. Harvey, in the early spring of 1924.

In its vegetative growth and asexual reproduction as observed when the plant was growing saprophytically on bits of seeds in water, it could hardly be distinguished from other saprophytic species of the genus. Its peculiar sexual organs, however, which are developed under nearly all conditions of culture serve to readily distinguish the plant from all other members of the genus. From the two plants to which it seems closest, *A. phycophilus* and *A. parasiticus*, it can easily be distinguished by the larger oogonia and eggs of the former, and the smaller oogonia and eggs of the latter, and also by the fact that the first mentioned plant is an obligate parasite on *Spirogyra*, while the second mentioned one is an obligate parasite within the threads of *Achlya*.

The mycelium of this peculiar plant when growing saprophytically on bits of boiled corn grain, hemp seed, etc., or on ant larvae or grubs in water presents much the same appearance as does that of other saprophytic members of the genus. On corn meal agar made up according to our standardized formula (4 heaping teaspoons corn meal in 1 liter of water heated over water bath 1 hour. Filter. To filtrate add 12 grams agar. Autoclave 15–30 minutes 10–15 lbs. pressure), the fungus grows rather slowly as compared with most other water molds, growing at about the rate of 0.5–0.7 cm. every twenty-four hours, while *S. ferax*, to give an example of a rapid grower, grows at least 2 cms. every twenty-four hours. The mycelium on agar while not so dense as in other saprophytic species in the genus is made up of thicker, more sinuous, and more branched threads. When growing saprophytically on agar, there quite often grow out from the main threads numerous, short, much branched, rhizoid-like threads much like those entwining the host threads when the plant is growing semi-parasitically.

When growing in water on bits of vegetable or animal material in company with another water mold as a *Pythium*, or an *Achlya*, the *Aphanomyces* hyphae develop numerous branched, rhizoidal attachments which fix themselves to the hyphae of the host. These rhizoidal branches, which may be regarded as superficial haustoria, twine around the threads of the host, establishing a very intimate communication with them. Since the material was not studied by sectioning and staining, it is impossible to say just what were the relations between the protoplasm

of the parasite and that of the host. A painstaking search was made on living material with a Leitz binocular and an apochromatic oil immersion objective to find cases in which the walls between host and parasite were dissolved. Only a few clear cases could be found, one of which is shown on plate 33, fig. 10. Here, at the letter A, the host wall seemed to have disappeared entirely, thus permitting a direct communication between the protoplasm of the parasite and host. In no case could any interchange of protoplasmic material be observed. The effect upon the host, however, is very marked and rapid. The protoplasm of the host threads in infected regions soon becomes disorganized, presenting a coarsely irregular, granular, vacuolate appearance. The host thread, apparently in order to protect itself, establishes a cross wall between the healthy and unhealthy regions. Meanwhile the haustoria multiply until in many cases they completely cover the host thread for a considerable distance. The parasitized regions in the host threads finally present a glistening look as though either empty except for sap or filled with oil. The osmic acid test failed several times to give an oil reaction, while Congo red gave a decided reaction for cellulose in the parasitized region.

The mycelium when growing in water forms numerous sporangia which may begin discharging their spores within twenty-four hours after the substratum was inoculated. The development of the sporangia, the discharge of the spores and their subsequent history parallels that in the other commoner species.

The oogonia are formed under most conditions of culture. They are developed in greatest abundance when the plant is growing on corn meal agar in the presence of a congenial host, as *Pythiopsis cymosa*. Many are formed when grown as a pure saprophyte on corn meal agar. A fair number are formed when growing on bits of corn grains in water in the presence of another watermold, while only a few are formed on purely saprophytic cultures in water.

When growing on agar, the oogonia are formed in daily concentric circles, the first circle appearing after about two days about 1.5 cms. from the point of inoculation. The width of the circle when the fungus was growing on our standard corn meal agar, with the temperature about 22°C., in company with *Pythiopsis cymosa* was about 0.4–0.5 cm.

This regular daily appearance of a new circle of oogonia offers a parallel case to the daily appearance of a circle of sporangia in *Thraustotheca primoachlya*, and *Achlya orion* and is of particular interest as it complements the work of Smith ('21) on *Saprolegnia diclina*, in which he

found that by far the greater part of the nuclei divided during the latter part of the night to form the spores on the following day.

EXPERIMENTS TO DETERMINE THE RANGE OF PARASITISM

Numerous experiments have been made to determine the range of the growth habits of the plant. The fungus as has been mentioned above was first found growing with and parasitizing many of the threads of an unidentified species of *Pythium* in water on a piece of corn grain. Single spore cultures were made by isolating a cluster of the *Aphanomyces* spores and placing the cluster on a corn meal agar plate in a drop of water. About ten hours later many of the spores had emerged from their cysts, and sprouted into minute germ tubes. Several of these sprouting spores were cut out and separately planted on fresh corn meal agar plates. A strain descended from a single spore culture has been used in making the preceding descriptive notes and the following experiments.

Several attempts have been made to induce the plant to grow as a pure parasite on the threads of other molds in water. All efforts however in this line so far have been unsuccessful. The probable explanation is that the parasite grows very poorly in water, while all the other species tested grow very luxuriantly in water. The tests were made as follows: young cultures of the prospective host and parasite growing on bits of boiled corn or hemp seed were put in the same Petri dish so that their threads were in contact. It was anticipated that the parasite would attack the prospective host threads and then that the connections between the parasitized area and the saprophytic substratum might be severed by cutting the *Aphanomyces* threads, after which, if the *Aphanomyces* were capable of living as a pure parasite, it would continue to grow receiving its food entirely from the host. The results of these experiments may be summarized as follows:

1. *Aphanomyces* × *Saprolegnia ferax*, young culture. No parasitism, the *Saprolegnia* overgrew the *Aphanomyces* substratum.
2. Experiment repeated with same results.
3. Experiment repeated, except a mature culture of the *Saprolegnia* was used; results as above.
4. *Aphanomyces* × *Achlya* (sp.), young culture. No parasitism, *Achlya* overgrew the *Aphanomyces* substratum.
5. Experiment repeated, except an old culture of the *Achlya* was used, with same results.
6. *Aphanomyces* × *Dictyuchus monosporus*, oogonial strain A. No parasitism. *Dictyuchus* overgrew *Aphanomyces* substratum.

7. *Aphanomyces* × *Dictyuchus monosporus*, antheridial strain. No parasitism. *Dictyuchus* overgrew *Aphanomyces* substratum.
8. *Aphanomyces* × *Pythium* sp. *Pythium* threads slightly parasitized only where the threads of the two plants were placed in contact. *Aphanomyces* did not spread over the *Pythium* culture.

Since the *Aphanomyces* would not grow well in water it seemed advisable in testing the range of the plant's parasitic habit to grow it on corn meal agar plates, a substratum on which the fungus grows well. The tests were made by inoculating a corn meal agar plate with threads from a pure culture of the parasite and also pure threads of the prospective host. The two fungi were usually placed about 2 cms. apart. Phycomycetes, Ascomycetes, and one Basidiomycete have been used in making the tests.

Several types of reactions have been obtained which may be summarized as follows:

1. Host inhibited, the parasite not inhibited, the latter forming a perfect circle of growth. Host threads parasitized.
2. Host plant considerably or entirely inhibited, the parasite more or less inhibited. Host threads parasitized.
3. Mutual inhibition, parasitism.
4. Prospective host at first inhibited and parasitized but later overgrowing the *Aphanomyces*.
5. Mutual inhibition, no parasitism.
6. Prospective host not inhibited, the *Aphanomyces* inhibited and unhealthy in region next to the prospective host. No intermingling of threads.
7. Type of reaction depending upon temperature.

1. Host inhibited and much parasitized, parasite not inhibited, the latter forming a perfect circle of growth (see pl. 28, fig. 1). All members of the *Saprolegniaceae* tested gave this general type of reaction, including *Pythiopsis cymosa*, *Achlya orion*, *A. megasperma*, *Thraustotheca clavata*, *T. primoachlya*, and *Dictyuchus monosporus* (both oogonial and antheridial strains). Most of the above species are rather slow growers on corn meal agar, growing as slowly as or even more slowly than the *Aphanomyces*. In the case of *Saprolegnia ferax*, however, which grows very rapidly, the *Aphanomyces* parasitizes it and inhibits its growth somewhat but the threads of the latter turn aside and grow around the parasite, finally completely overrunning it.

All members of the genus *Pythium* tested gave the same general type of reaction as that described above for *Pythiopsis cymosa*, *Achlya orion*, etc. The photograph (pl. 26) shows a plate of *Aphanomyces* and

Pythium sp. in which the *Pythium* is parasitized and its growth inhibited while the parasite continues its growth.

Using this species of *Pythium* (No. 53) as a host, some experiments were carried out to see if immunity was acquired by the host after it had been parasitized. Host threads out on the margin of the contact zone which were parasitized in a region three or four millimeters back from the tips were cut out in agar squares (fig. 4) and placed on a corn meal agar plate at the same time with a square of agar containing the *Aphanomyces* threads (fig. 5). The *Pythium* below and on the sides was not parasitized and considerably overgrew the *Aphanomyces*, in the middle above (fig. 5). Agar squares containing *Pythium* threads from this non-parasitized growth were now cut out and put on a plate with the *Aphanomyces* and in this experiment the *Pythium* was parasitized as formerly. This series of experiments was repeated with the same results. It seems, therefore, that a temporary immunity may be acquired by the *Pythium*.

2. Host plant considerably or entirely inhibited, the parasite more or less inhibited. Host threads parasitized. This type of reaction was obtained in crosses with species of *Mucor* as *Mucor genevensis* and *M. Vuillemini*. Both of these species grow at about the same rate on corn meal agar as the parasite, and therefore when one of these Mucors was planted with the parasite on opposite sides of the dish, their threads would meet after about two days in the center of the dish. When the threads of the host and the parasite touched, the host threads stopped growing; the parasite, however, though much slowed down, continued its growth for some distance among the host threads, parasitizing them. Reactions with *Mucor parasiticus* (*Parasitella simplex*) also belong in this type. This latter species grows, as a rule, rather slowly as a saprophyte on corn meal agar, the intramatrical hyphae being rather sparingly developed. The *Aphanomyces* when plated with this plant continued its growth within the agar, parasitizing the intramatrical threads of the mucor. The growth of the mucor was inhibited.,

Reactions with *Rhizopus nigricans* might also be put in this type, but the *Rhizopus*, when its intramatrical hyphae were impeded and parasitized by the *Aphanomyces*, resorted to the method of spreading over its substratum by stoloniferous growth, and spread slowly over the *Aphanomyces* culture. Wherever the *Rhizopus* threads or runners came in contact with the agar and sent down rhizoids among the *Aphanomyces* threads, the latter quickly parasitized the *Rhizopus*.

In a culture of *Rhizopus* with *Aphanomyces* some observations were

made on the early stages of infection. The two fungi planted on the same dish May 5 were just coming in contact May 8, the *Rhizopus* threads having grown to a length of 4 cms., the *Aphanomyces* threads 1 cm. Out on the margin where the threads of the two fungi were apparently approaching each other but were not yet in contact, a *Rhizopus* and *Aphanomyces* thread which were growing in such directions that they seemed as though they would come in contact were selected for observation. After several minutes the *Aphanomyces* thread changed its direction of growth, slightly bending away from the *Rhizopus* thread which was growing toward the *Aphanomyces* at a rapid rate. At this stage the two hyphae were sketched (plate 33, fig. 1); they were 0.07 mm. apart. Figure 2 was made five minutes later and in two minutes more the two threads were in contact (fig. 3).

In seven minutes the *Rhizopus* thread had grown 0.07 mm. not counting the bending away of the *Aphanomyces* thread. In this case only the tip of the *Rhizopus* thread touched the *Aphanomyces*, and yet within three minutes after the two threads were in contact the protoplasm of the *Rhizopus* thread for a considerable distance from the tip back was becoming very coarsely granular and showing marked signs of disorganization (fig. 4). In five minutes more the part of the *Rhizopus* thread in which the contents were disorganized was cut off from the healthy part of the thread by a cross wall (fig. 5). The parasite having killed part of the host thread now quickly sends out one or more small threads which coil about the host (fig. 6).

The above observation repeated several times in cultures of *Aphanomyces* with *Rhizopus* and the numerous other Phycomycetes parasitized showed that no lethal substance is given off which kills the host in advance but that the host threads are killed only when in contact with the parasite and then with remarkable rapidity.

3. Mutual inhibition, parasitism. Both organisms grow toward each other until they are in contact. The *Aphanomyces* parasitizes the other fungus only along the lines of contact, only a slight intermingling of threads. This type of reaction results when the parasite is plated with other species of the same genus, as *Aphanomyces laevis* (see pl. 28, fig. 2).

4. Prospective host at first parasitized but later overgrowing the *Aphanomyces*. This type of reaction was obtained when the *Aphanomyces* was cultured with *Syncephalis* sp. The *Syncephalis* grows at about the same rate as the *Aphanomyces*, the two fungi meeting about the center of the dish. In the region where the two fungi met, the

Syncephalis was parasitized. Its growth however was not inhibited; on the contrary it rapidly overgrew the *Aphanomyces* culture preferring the region of agar occupied by it to the region of agar as yet unoccupied by either fungus. These two fungi have been cultured together several times and a careful search was carried out for a case where the *Syncephalis* (which is a facultative parasite on *Mucor* species) was parasitizing the *Aphanomyces* but no such condition could be found.

5. Mutual inhibition, no parasitism. Both organisms grow toward each other until they are in contact or nearly in contact and then growth ceases, both organisms remaining healthy. This type of reaction is obtained when two cultures of the parasite are plated together and when the *Aphanomyces* is plated with *Sordaria* sp. (pl. 27). The *Sordaria*, which is a very rapid grower on agar, growing at about the rate of 3.5 cms. a day in summer room temperature, far outstripped the *Aphanomyces* in growth. The threads of the two fungi somewhat intermingled along the line of contact, the *Sordaria* forming a dense row of perithecia along this line. Practically the same results were obtained when the parasite was plated with *Aspergillus niger* and several species of *Penicillium* except that neither of the latter formed perithecia.

6. Prospective host not inhibited, the *Aphanomyces* inhibited and unhealthy in the region next the prospective host. No intermingling of threads. The *Aphanomyces* threads near the ends of the contact region curving considerably to avoid the prospective host and those near the center of the contact region showing a very unhealthy condition, apparently dying. This type of reaction resulted between the *Aphanomyces* and *Schizophyllum commune*. No other Basidiomycetes have been tested.

7. Type of reaction depending upon temperature. Cultures of *Aphanomyces* with *Allomyces arbuscula* belong in this type. A culture was made Sept. 14 and kept in room temperature. On Sept. 30 the culture was examined: the *Aphanomyces* had covered the agar plate while the *Allomyces* had grown very poorly, the longest threads reaching a length of 0.4 cm. The *Allomyces* was much parasitized (fig. 6).

Another inoculation was made Sept. 10 and kept in the oven with the temperature at 34°C. At this temperature the *Allomyces* grew luxuriantly while the *Aphanomyces* grew poorly. Examined and figure 7 made Sept. 18. No parasitism. The *Allomyces* threads overgrowing the *Aphanomyces* cultures, the *Allomyces*, however, being slightly slowed up in this region. The *Aphanomyces* threads showed a very peculiar

branching habit near their outer margin of growth, the individual threads branching considerably and becoming thicker and septate in places, resembling in appearance the threads of *Allomyces*.

Another culture was made Sept. 14 and kept in the oven with the temperature at 34°C. for two days. The *Aphanomyces* grew very poorly; the *Allomyces* grew to a length of about 1 cm. from the point of inoculation. The culture was removed to room temperature on Sept. 16. Examined and figure 8 made Sept. 30. The *Aphanomyces* had covered the dish; the *Allomyces* had grown very slightly after being changed to room temperature but had formed many sporangia. The *Aphanomyces* was parasitizing the *Allomyces*, attacking the sporangia usually.

Several attempts were made to induce the plant to grow as a parasite on algae. Two species of *Spirogyra* were used, one a fairly large species with 4–5 chromatophores; the other a smaller species with one chromatophore. Squares of agar containing growing, healthy threads of the fungus were cut out and placed on the *Spirogyra* threads. The *Aphanomyces* threads grew out in considerable numbers to a distance from the agar of 2–4 mm., forming numerous sporangia from which spores were discharged. These experiments were kept under observation for three weeks but no infection took place.

DISCUSSION

Kern ('15) discusses briefly parasites as an aid in determining genetic relationships in their hosts, citing some evidence from his own work which seems to show that parasites may be used as an aid in discovering specific and generic relationships.

Matruchot ('03) has shown that *Piptocephalis Tieghemiana* would live as a parasite on any of the Mucorales but would not parasitize any fungus from any of the other groups, numerous types of which were tested. He concluded therefore that the parasitism of *P. Tieghemiana* on any fungus showed the taxonomic relationship of that fungus to the Mucorales. On this basis with the absence of sexual reproduction, he classed *Cunninghamella africana* Matruchot (= *C. echinulata* Thaxter) with the Mucorales. Blakeslee ('05) shortly afterwards reported the zygotes of this form, thus showing conclusively that this plant belonged to the Mucorales.

In the experiments which have been described above for *Aphanomyces exoparasiticus* a similar relation has been shown to exist between host and parasite as that described by Matruchot ('03) for *Piptocephalis*

Tieghemiana, and it might be concluded with a reasonable degree of assurance, provided there were no structural characters to negative the reasoning, that an unknown fungus which the *Aphanomyces* would use as a host was a Phycomycete.

SUMMARY

1. The genus *Aphanomyces* may be subdivided according to the growth habits of its species into three groups: (1) Usually saprophytic in nature but occurring also as a parasite; (2) Usually parasitic in nature but culturable as a saprophyte or as a parasite and a saprophyte at the same time; (3) obligate parasites.

2. *Aphanomyces phycophilus* is reported for the first time in the eastern United States.

3. A heretofore unreported form of *A. laevis*, distinguished by the occasional spiny oogonia and the rare occurrence of two eggs in the oogonium, is described.

4. A species of *Aphanomyces* closest to *A. parasiticus* but differing from that species in the size of the oogonia and eggs and especially in growth habits is described as new with the name *A. exoparasiticus* because of its habit of sending its haustoria around the threads when growing as a semiparasite on other molds.

5. Numerous experiments are described which have been carried out to determine the range of parasitisim of the new species. It has been found that the new species parasitizes all Phycomycetes tested, but that Ascomycetes and Basidiomycetes so far tested are immune. *Spirogyra* also is immune.

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EXPLANATION OF PLATES

PLATE 28

Fig. 1. *Aphanomyces exoparasiticus* above with *Pythiopsis cymosa* below. Cultures five days old. The *Aphanomyces* had formed a perfect circle of growth and three distinct concentric circles of oogonia. The *Pythiopsis* was checked in its growth when it came in contact with the *Aphanomyces* and was much parasitized.

Fig. 2. *Aphanomyces exoparasiticus* above with *Aphanomyces laevis* below. Cultures five days old. Mutual inhibition, with a very slight intermingling of threads. Parasitism along the line of contact. The parasite with three distinct circles of oogonia, while the three denser regions of the host are formed by considerable branching of the hyphae.

PLATE 29

Fig. 3. *Aphanomyces exoparasiticus* above with *Pythium* No. 53 below. Cultures three days old. *Aphanomyces* parasitizing the *Pythium*.

Fig. 4. Same as above but two days later. The growth of both plants inhibited, the *Pythium* much more than the *Aphanomyces*. At this time blocks of agar containing *Pythium* threads which had grown through the parasitized region where cut out at the places indicated by the two squares on the sides and put on a fresh corn meal agar plate with inoculum of the *Aphanomyces*. See pl. 30, fig. 5.

PLATE 30

Fig. 5. *Aphanomyces exoparasiticus* and *Pythium* No. 53 inoculated September 14. Examined and figure made Sept. 30. No parasitism. The *Pythium* encroaching upon the *Aphanomyces*.

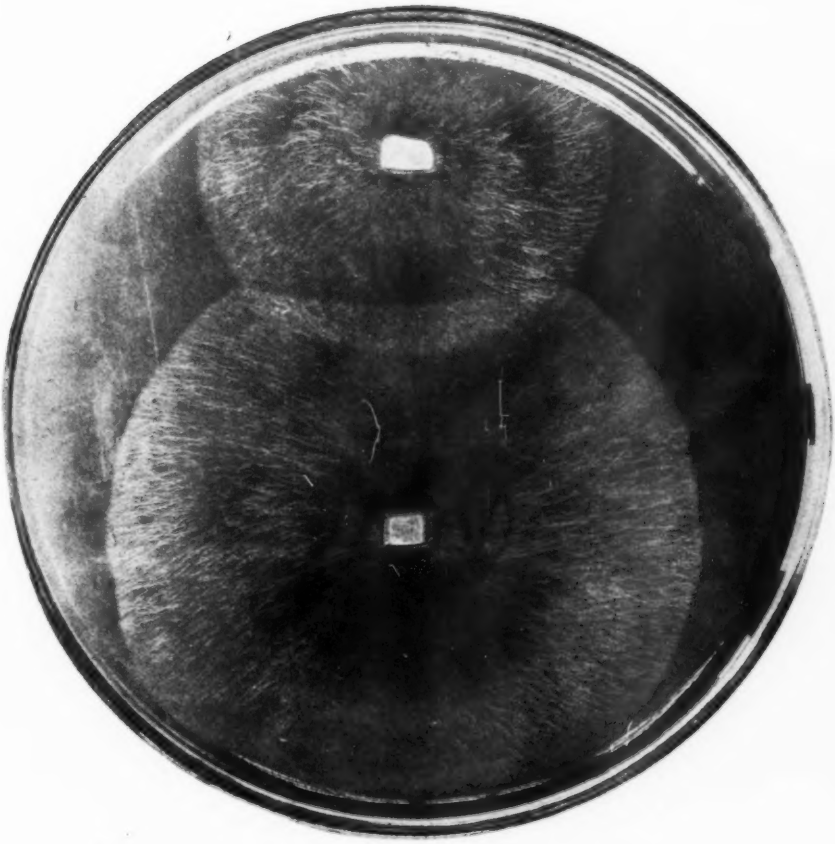
Fig. 6. *Aphanomyces exoparasiticus* above (two inoculations) with *Allomyces arbuscula* below, Sept. 14. In room temperature. Figure made Sept. 30. *Aphanomyces* had covered dish; *Allomyces* had grown very poorly, about 0.4 cm. and was much parasitized.

PLATE 31

Fig. 7. *Aphanomyces exoparasiticus* with *Allomyces arbuscula* inoculated on Sept. 10 and kept in the oven with the temperature at 34°C. Figure made Sept. 18. The two mats of luxuriant growth below are *Allomyces* while the dwarfed culture to the right above is the *Aphanomyces*. No parasitism.

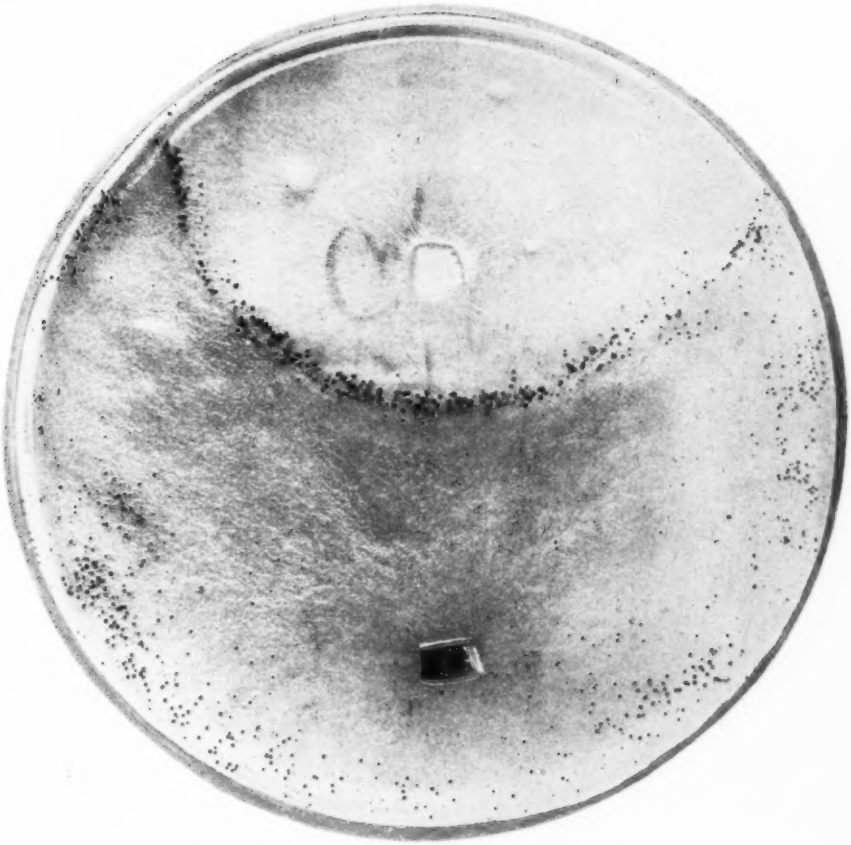
Fig. 8. *Aphanomyces exoparasiticus* above (two inoculations) with *Allomyces arbuscula* below and kept in the oven at 34°C. for two days. Changed to room temperature. Figure made 14 days later. Note the two regions of growth in the *Allomyces:* the inner region formed while the culture was in the oven; the outer, thinner region while out in room temperature.

PLATE 26



Aphanomyces exoparasiticus (above) with *Sordaria* sp. (below). × 1¼

PLATE 27



Aphanomyces exoparasiticus (above) with *Pythium* sp. (below). ×1½

PLATE 28

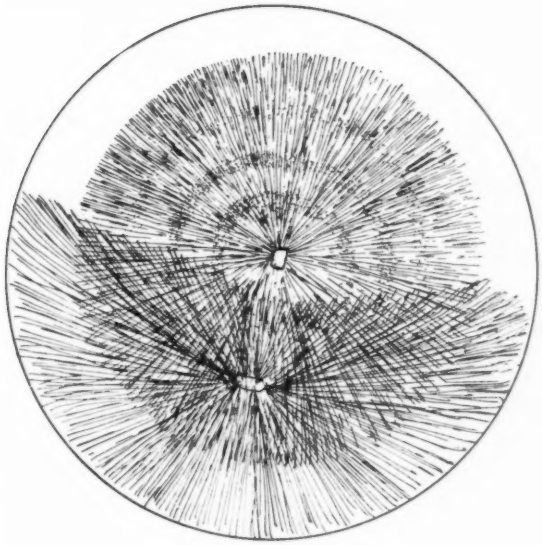


FIG. 1

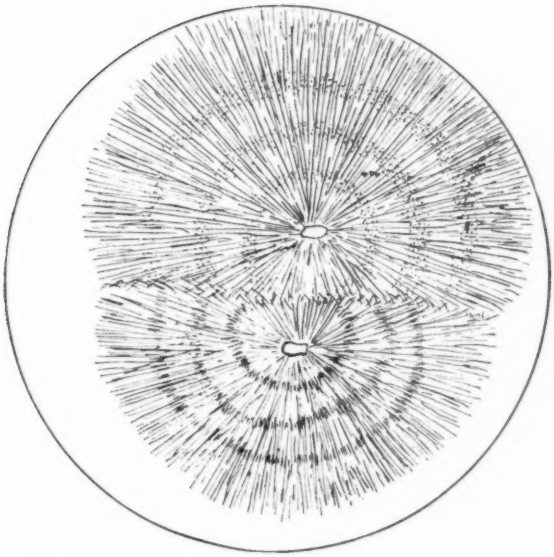


FIG. 2

PLATE 29

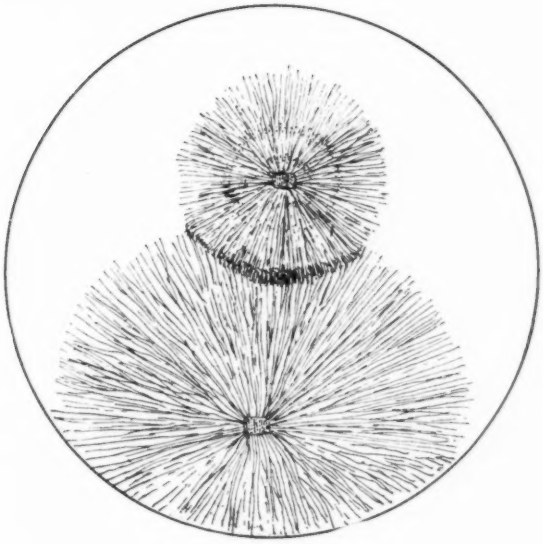


FIG. 3

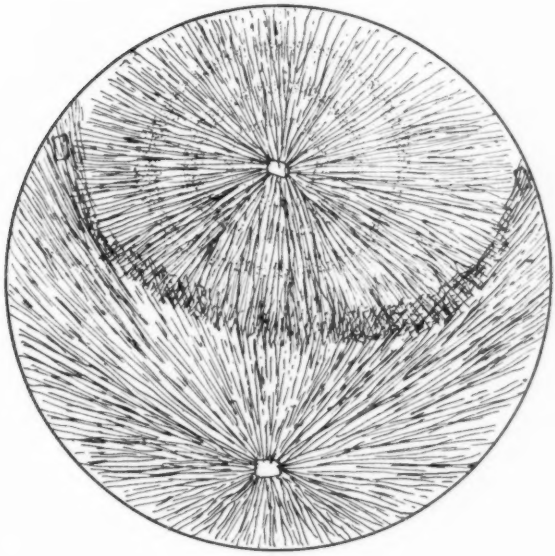


FIG. 4

PLATE 30

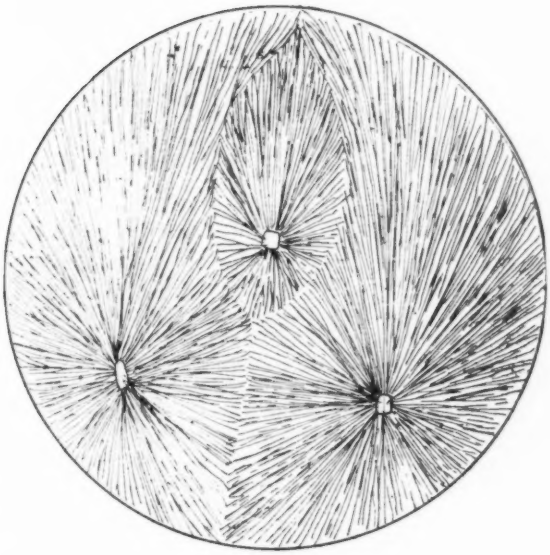


FIG. 5

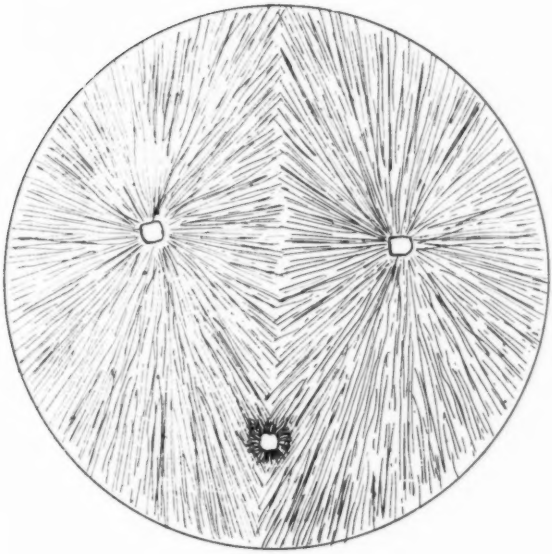


FIG. 6

PLATE 31

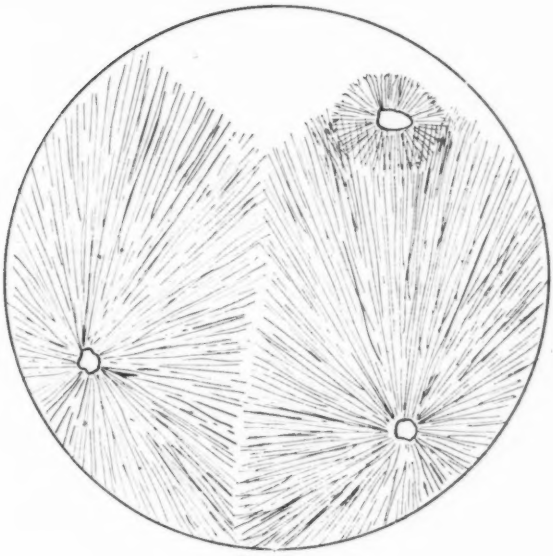


FIG. 7

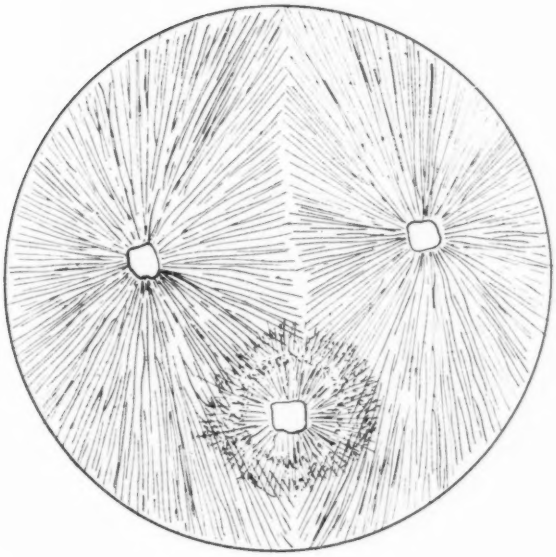


FIG. 8

PLATE 32

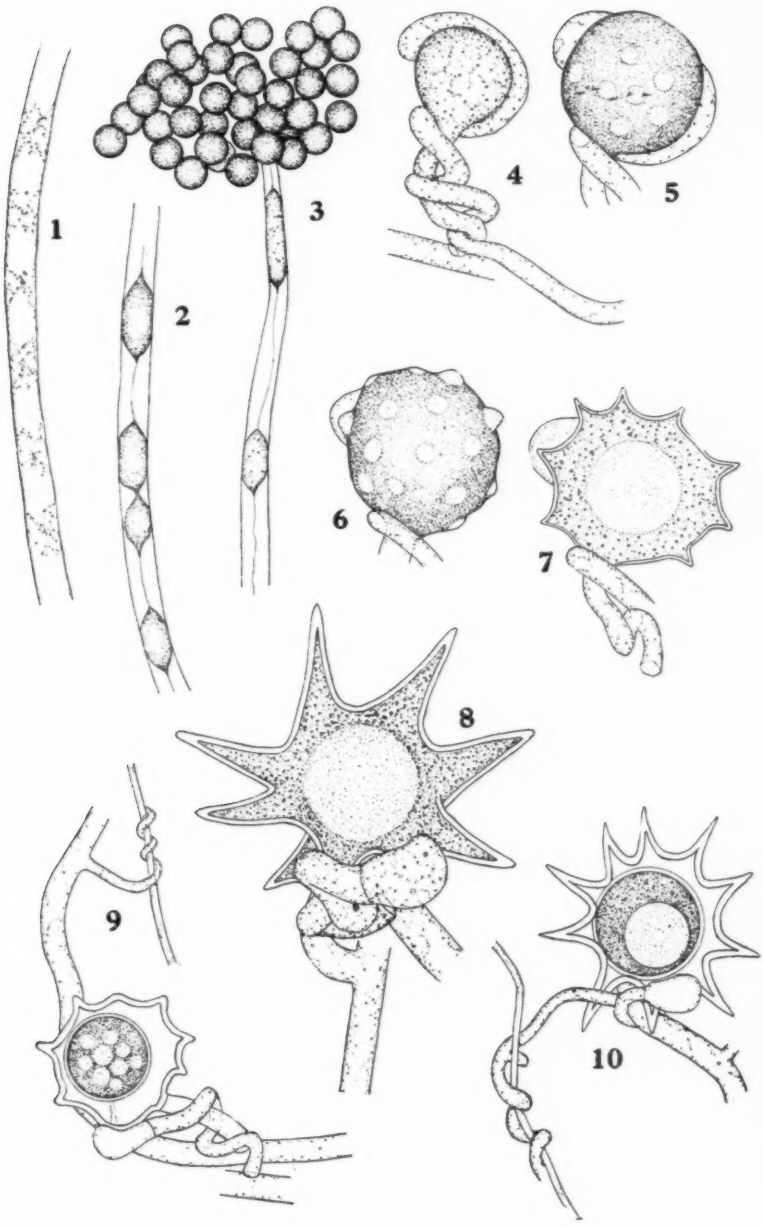


PLATE 33

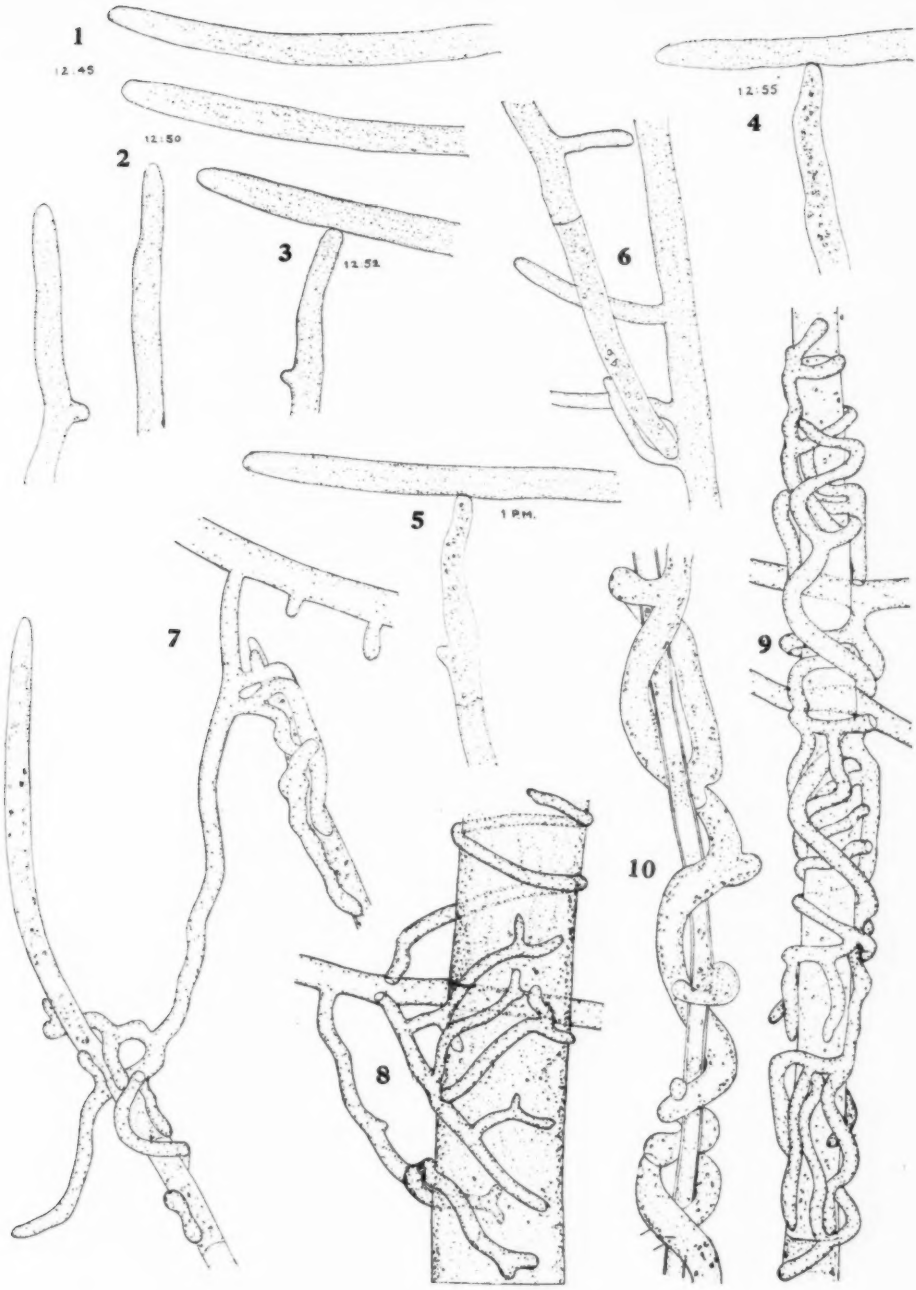


PLATE 32

Aphanomyces ezoparasiticus

Figs. 1, 2, 3. Parts of sporangia showing stages in spore development and emergence. × 502.

Figs. 4–7. Stages in the development of an oogonium. Figures drawn 11 A.M., 2.15 P.M., 5 P.M., and 9 P.M., respectively. × 810.

Fig. 8. Oogonium with characteristically long spines. Twelve spines were visible on this oogonium but only eight are shown in section view. × 1012.

Fig. 9. Oogonium containing a nearly ripe egg. Parasitized *Pythium* thread above. Note empty antheridium and old antheridial tube. × 562.

Fig. 10. Oogonium containing a ripe egg. Antheridial branch arising from a thread coiling around and parasitizing a *Pythium* thread. × 562.

PLATE 33

Aphanomyces ezoparasiticus

Figs. 1–5. Early stages in the infection of a *Rhizopus* thread by the *Aphanomyces*. The *Aphanomyces* threads above and horizontal; the *Rhizopus* below and perpendicular. See text. × 413.

Fig. 6. *Aphanomyces* thread to the right sending out a small haustorium around *Rhizopus* thread. Note the cross wall separating the unhealthy region of the *Rhizopus* thread from the healthy. × 413.

Fig. 7. *Aphanomyces* parasitizing the small threads of *Achlya megasperma*. The protoplasmic contents of the parasitized region of the thread in the lower left corner is much vacuolated and coarsely granular; a cross wall separates the unhealthy from the healthy region. × 413.

Fig. 8. A larger thead of *A. megasperma* in early stage of being parasitized. × 413.

Fig. 9. Thread of *A. megasperma* almost completely covered by the *Aphanomyces* haustoria. The *Achlya* thread in this parasitized region seemed to be practically empty of its protoplasmic contents, giving a deep red reaction with congo red while the healthy regions at the ends were very lightly stained. Note the cross walls separating the healthy from the unhealthy region. × 413.

Fig. 10. *Pythium* thread parasitized by the *Aphanomyces*. Note the apparent connection between the host and parasite protoplasm on the right about midway. × 900.

PLANKTON COLLECTIONS IN LAKE JAMES, NORTH CAROLINA—COPEPODS AND CLADOCERA

By R. E. Coker

Plates 34–44

Lake James

Lake James is a relatively large and deep lake in Burke and McDowell counties, formed by the damming of three headwater streams of the Catawba River. These streams are the Catawba River, Paddy's Creek and Linville River, each being separately dammed although but one lake is formed. Topographic conditions made it desirable not to build a single dam on the Catawba River below the entrance of its tributaries, but to dam each stream a short distance above the points of natural junction and then, by cross connections, natural or artificial, to join the lakes and make a single reservoir. Paddy's Creek and Linville River were separated by so low a divide at one place that the two lakes became naturally connected as soon as the water level was raised. The dam on Catawba River was placed about 3 miles westward from the lower eastern ends of the other lakes, and the lower end of Catawba Lake was effectively connected with the upper part of Paddy's Creek Lake only by the excavation of a broad but short canal. There are thus three lakes in one, each division being commonly known by its own name, while the name of the single lake system is rarely employed by fishermen. The several component lakes are subject to different influences and seem to present individual characteristics, at least from the point of view of the angler.

Linville Lake, the easternmost unit of the system, has a length of 5 miles and a width varying from $\frac{1}{2}$ to 1 mile or more. It is straight and open, although its shores are marked by several deep coves, and one large arm extends off from its lower end. Paddy's Creek Lake is smaller, having a length of about $3\frac{1}{2}$ miles and a width varying from $\frac{1}{4}$ to about a mile. In each of these lakes one may look from near the head to the very foot of the lake. Catawba Lake presents a very different appearance: with a length of 7 miles and a width varying from $\frac{1}{4}$ to $\frac{1}{2}$ mile

between headlands, its course is so winding that nowhere on its shores can one see another point of the shore at a distance much exceeding 2 miles.

The lake system has an area of approximately 10 square miles (about 6600 acres). When it is said that the length of the shore line is a little less than 150 miles, it is evident that the shores are winding and deeply indented, a condition arising from the semi-mountainous character of the region. The lakes are, indeed, at the very foot of the Blue Ridge Mountains, the upper end of Linville Lake being but a mile or two below Short-off Mountain which marks the lower limit of Linville River Gorge, and the greater part of Catawba Lake being only about 4 miles from the very summit of Bald Knob with its elevation of 3546 feet. The crest of the spillway (Catawba River dam) is at 1200 feet. The greatest depth of water is about 130 feet.

For protection of the turbines in the power plant, the flooded area was cleared of forest growth before the water was raised and the shores are kept as free as possible from materials that might become drift-wood, although green forests extend to the water's edge. The high hills rising steeply from the shores, the numerous ravines, deep coves and promontories, and a few islands give the appearance of natural mountain lakes rather than of waters impounded by man for economic ends. This is the aspect when the water level is up; it is said, however, that the level is sometimes lowered as much as 55 feet.

A peculiar biological condition of the lake at the time the collections were made was the virtual absence of all common shore minnows (Cyprinidae). The only fish that I could collect in the lake itself were bass, *Micropterus salmoides*, pumpkin-seed sunfish, *lepomis gibbosus*, long-eared sunfish, *L. auritus*, warmouth, *Chaenobryttus gulosus* (all these were abundant), a very few shiners, *Notropis procne*, silver-fin shiners, *N. hudsonius*, black suckers, *Catostomus nigricans*, white suckers, *C. commersonii*, and the yellow catfish, *Ameiurus nebulosus*. A few other species were reported to be present, and these are mentioned in another paper, where also may be found observations of hydrogen-ion concentration.[1] Practically everywhere the water was barely on the alkaline side of neutrality, pH 7.2–7.4: this applies to all plankton stations, except station 13, in the mouth of Catawba River, where slight acidity was indicated by the record pH 6.9.

Rooted aquatic plants are virtually absent from the lake, owing, no doubt, to the fluctuations of level and the general steepness of the shores,

[1] Observations of hydrogen-ion concentration, etc. Ecology 6: 52–65. 1925.

and this condition has a marked effect on the variety and the distribution of Entomostraca in the lakes. Many expected species are not represented in the collections. Furthermore, the zoo-plankton taken with nets consisted almost exclusively of Cladocera and copepods.

DISCUSSION OF COLLECTIONS

All collections were made at the surface with plankton nets on rings 12 inches (30 cm.) in diameter and made, one of No. 10 bolting silk throughout, the other with top of No. 0 and bottom of No. 3 bolting silk. Each net was 3 feet deep, with open canvas sleeve at the small end into which a large-mouthed bottle was tied when the net was used. In each case the net was dragged for a distance of about 50 yards. As special attention was not given to the minute algae, no notable difference was observed between the catches made with the finer and coarser nets, respectively; comparisons, so far as made, are based on collections made with the coarser net.

The dozen collections available are not sufficient for general inferences concerning distribution of species in the lake, but it is appropriate to submit the following notes regarding the several stations and the species collected at each.

Station 5, the first in Catawba Lake, was very near shore at the mouth of a small bay on the north side of the lake. Although plankton was very limited in quantity, this collection yielded more than the usual (for this lake system) number of species. Daphnia and Scapholeberis predominated; Diaphanosoma, Diaptomus, *Cyclops leuckharti*, Ceriodaphnia and Bosmina were also present, the forms being named in order of abundance. Casts of dipterous larvae (chironomids, etc.), miscellaneous remains, and desmids and filamentous algae were relatively abundant.

Station 6 in open water between shores less than half a mile apart, yielded only 3 species, Daphnia greatly predominating. Diaptomus, though few relative to Daphnia, were actually as abundant as Daphnia at station 5. Scapholeberis were present in small numbers, and a single example of Simocephalus was found. There were a few casts of chironomids, and algae were abundant, represented by Desmidium, Aptogonium, Ulothrix and others.

Station 7, similar to 6, but half a mile to westward, revealed a nearly pure culture of Daphnia, with a rare Diaptomus, Cyclops, and Diaphanosoma, but this was the poorest collection made. Casts of Diptera were common.

Station 8 in Deal Bay yielded chiefly Diaptomus, with some Daphnia and Bosmina, a few *Cyclops leuckharti* and a Chydorus. Station 9, also in Deal Bay, but closer to shore, yielded almost no living Entomostraca: only an occasional Daphnia or Diaphonosoma could be found in a mass of debris with desmids (Desmidium, Micrasterias, etc.) and other algae; a single female Diaptomus, casts of young *Cyclops leuckharti* and one or two ostracods were encountered.

The collection from station 10, with conditions similar to those of stations 6 and 7, but 3 miles to westward of 6, was limited in quantity and an almost pure culture of Daphnia; an occasional Diaphanosoma could be found, and algae were common.

At station 11 we were nearing the head of the lake; it might better be said that the lake proper here meets the broad flats below the mouths of the two branches of the upper Catawba River. Here was the greatest variety of species, but all appeared in small numbers, except Daphnia, which was about as abundant as at any previous station. Diaptomus. *Cyclops leuckharti* (and nauplii) and Bosmina were in small numbers; *Cyclops prasinus* Diaphanosoma, Ceriodaphnia, Chydorus, and Alona [2]? were rare; Dipterous larvae were common; Aptogonium, Hyalotheca and other algae and amorphous matter were abundant.

We then passed into the expanded upper end of the lake and to the weedy flats a quarter of a mile below the highway bridge, which may be said to mark the upper limit of Catawba Lake. As expected, plankton was present here, at station 12, in extreme abundance, the quantity taken being perhaps 50 times as much as at any previous station in this lake. Diaphanosoma, Daphnia, Diaptomus and Cyclops, in order of abundance, constituted the entire catch, except for a few Bosmina and still fewer examples of *Ceriodaphnia lacustris*.

Station 13 was made in the lagoonlike lower part of the South Fork of the Catawba just below the highway bridge, where the water was very shallow and sluggish in flow. This was the only place where the hydrogen-ion concentration was on the acid side of neutrality. Cladocera were much less abundant, although Daphnia was more numerous than at any other station except No. 12. A few Bosmina (but no Diaphanosoma) appeared. Diaptomus greatly predominated and was almost as abundant as at station 12. *Cyclops leuckharti* was present in small numbers, but was rivaled by *C. serrulatus*, the common form in small ponds, pools and aquaria. *Cyclops prasinus* was found and a

[2] A single specimen provisionally identified on *Alona* (and possibly *Alona costata*) was observed in collections from this station.

canthocamptid, Attheyella, was common. The great number of nauplii was notable. Insect remains and debris were, of course, abundant. We have, then, a few lake-inhabiting forms consorting freely with forms characteristic of small ponds.

It is notable that the one species of Entomostraca running throughout Catawba Lake was *Daphnia arcuata catawba*. It occurred at all stations and generally led all species in abundance. It attained its maximum abundance at station 12 only to be out-ranked by the still more numerous Diaphanosoma. Even at station 13, where copepods largely prevailed and all species of Cladocera other than Daphnia seemed to be practically crowded out, it was still present in substantial numbers.

Diaptomus birgei was almost as generally distributed as Daphnia, but was entirely missing at open-water stations, and it rivaled or exceeded Daphnia in numbers only at station 8 and in the lagoonlike conditions existing in the river at the upper end of the lake.

No Cyclops were found in the lake except at the very head and near the shores; this applies also to Bosmina. It will be seen that in Paddy's Creek Lake, too, the distribution of Bosmina seemed to correspond with that of *Cyclops leuckharti*. Four species, Ceriodaphnia, Chydorus, Alona (?), and Attheyella, were found but very rarely.

With reference to the general distribution of Daphnia and Diaptomus in Catawba Lake, it is pertinent to say that, in November, 1923, when there was a plankton swarm in the city reservoir of Durham, N. C., nearly 200 miles east of Lakes James, several collections were made and were found to comprise exclusively *Diaptomus birgei* and a species of Daphnia. *Diaptomus birgei* may therefore be presumed to be widely distributed in North Carolina. As will be noted on another page, North Carolina has been supposed to be entirely without the range of *Diaptomus birgei*.

The easternmost station in Paddy's Creek Lake was in open water just north of the mouth of the canal connecting the lower end of Catawba Lake with the upper part of the former; the station (No. 15) was thus in the lower part of the upper fourth of Paddy's Creek Lake, or about $\frac{3}{4}$ of a mile from the upper limit of the lake. The lake is there about $\frac{2}{5}$ of a mile wide and of considerable depth, but, so near the source, a characteristic lake plankton was not to be expected. The collection, indeed, contrasted markedly, both in richness and in composition, with the nearer stations in Catawba Lake; it was more like collections from places in the upper part or near the shores of the other lake. Diaptomus predominated, Bosmina being a poor second, *Cyclops leuckharti* coming

third, then Daphnia and an occasional Diaphanosoma. No other species of Entomostraca were represented, but there were present casts of dipterous larvae, desmids (Micrasterias, etc.) and small mites.

TABLE I

Showing Relative Abundance of Copepods and Cladocerans in Certain Plankton Collections from Catawba and Paddy's Creek Lakes (Parts of Lake James, N. C.) in August, 1922

(All counts were made with Sedgewick-Rafter counting apparatus. Comparisons can be made as to relative abundance of species at a given station, but only rough comparisons between stations are permissible, since the several collections were made under conditions that were only approximately similar.)

SPECIES	PLACES, STATION NUMBERS AND COUNTS							
	Paddy's Creek Lake, just out Mouth of Creek	Catawba Lake, 30 feet from Shore, near East End	Middle of Catawba Lake, 1 mile from Dam	Catawba Lake above Deal Bay	Catawba Lake, at end of Neck near Head of Lake	Catawba Lake, just above Railway Bridge	Catawba Lake, 30 yards below Highway Bridge	Paddy's Creek Lake, above Connection with Catawba
	1	5	6	10	11	12	13	15
Copepods:								
Diaptomus birgei	132	5	30		10	3610	3040	760
Cyclops leuckharti	22	Oc.			20	2090	180	114
Cyclops prasinus					Oc.		?	
Cyclops serrulatus					R.		180	
Attheyella caroliniana							285	
Nauplii					20		3040	1082
Cladocera:								
Diaphanosoma	12	5		R.	R.	4940		R.
Daphnia	166	32	124	36	130	4465	855	48
Ceriodaphnia		R.			R.	R.		
Scapholeberis		23	8					
Bosmina	16	R.			R.	Oc.	19	285
Alona (?)					R.			
Chydorus					R.			

Oc., occasional; R., rare.

Stations 1 and 2 were at distances of about 20 and 300 yards, respectively, from the upper end of the lake, and the collections were similar in character: Daphnia was more abundant, being followed closely by

Diaptomus, with *Cyclops leuckharti*, Bosmina and Diaphanosoma in much smaller numbers. Casts of dipterous larvae and filamentous algae (Spirogyra, etc.) were common, and amorphous matter abundant.

No collections were made in the lower parts of this lake or in Linville Lake.

For comparison, two collections with the plankton net were taken in the swift waters of Paddy's Creek, about a hundred yards above the limit of backwater. No Entomostraca were found, but many casts of larvae of Diptera, Plecoptera and Ephemerida (Heptagenia), some small mites, a good deal of filamentous algae and plant remains, and abundant amorphous material.

It is well known that many species of Cladocera and Copepoda are of very wide geographic distribution, though exhibiting variations according to the conditions of the habitat. It is said that the same diversities of form are frequently to be found in regions remotely separated. As this is perhaps the first paper dealing with Entomostraca of North Carolina, and as the ecological relations are primarily in mind, I have thought it advisable to illustrate rather fully the diagnostic points in most of the species included in the following report.

CLADOCERA

SIDIDAE

The family Sididae was represented by a single species identified as *Diaphanosoma brachyurum* (Liéven) and found in extreme abundance in the lagoonlike upper portion of Catawba Lake. There, in an exceptionally rich plankton haul (Station 12), this species outnumbered such other very abundant forms as Daphnia, Diaptomus, and *Cyclops leuckharti*. A number of specimens were taken just out of the mouth of Paddy's Creek, an occasional one in a collection (15) a little lower in the same lake, and a very few in the lower and middle portions of Catawba Lake, always near shore.

Diaphanosoma brachyurum (Liéven)

Plate 34, figs. 1 to 4

The examples measured varied in length from 0.76 to 0.9 mm. In side view, the animal has somewhat the form of an elongated triangle with rounded angles, the head being at the apex of the triangle. The back is flattened, with distinct dorso-lateral angles bounding the long-

elliptical flattened median dorsal region (fig. 3). In preservative the animal is generally found with the valves of the shell widely outspread so that a side view is not readily obtained. There are about a dozen spinules at infero-posteal angles of valves, with fine denticles and ciliation before and after the spinules. The head is about $\frac{1}{4}$ the total length (shorter than stated by Herrick, 1895,[3] p. 149, but larger than figured by him). The diameter of the eye is about $\frac{1}{4}$ the length of the head; in dorsal view it may or may not completely fill anterior portion of head—that is to say, the head may be somewhat helmeted. The lenses on anterior and lateral surfaces of the eye are conspicuous, but the organ frequently appears indented on posterior side. The antennules are small, the blunt end bearing several setae and a flagellum.

The antennae extend nearly to posterior margin of shell; the undivided basal portion of each is very long and stout and bears a very delicate hair near its distal end on posterior side. The basal segment of the dorsal ramus has 4 lateral setae, one being approximately terminal; the distal segment has 6 lateral setae, and two terminal setae with a short spine. The ventral ramus is without armature on the very short basal segment, with a seta and a short spine at the end of the second segment, and with 3 setae and a short spine on end of third segment. The setae are jointed near middle, the outer part being smaller, very slender and easily broken away. The spinelike proximal portions of the setae bear numerous stiff lateral barbs, which were easily distinguishable only in stained examples.

The postabdomen is narrow, tapering to slender claws that bear slender spines near the base, graduated in length from proximal to distal; the claws bear 2 rows of very fine denticles, although only a small patch near the middle of claw may be distinguishable with ordinary powers; apparently the outer row of denticles does not extend more than half way to tip of claw. On the sides of the postabdomen are short rows of fine denticles forming a loop opposite anal opening and a few near origin of claw. No denticles were distinguished on the spines of claw.

The distinctions given by Birge (1918)[4] between *brachyurum* and the limnetic form (species or variety ?) *leuchtenbergianum* are the greater length of antennae and greater development of crest of head in the latter

[3] Herrick, C. L. Cladocera of Minnesota, pp. 139–276. Part II of Second Report of the State Zoologist, including a Synopsis of the Entomostraca of Minnesota. Zoological Series II. St. Paul, 1895.

[4] Birge, Edward A. The water fleas (Cladocera). Chapter XXII of Ward and Whipple's Freshwater Biology. New York, 1918.

form. In my specimens the reflexed antennae do not quite reach posterior margin of valves, although in many the crest is developed so that the head extends well beyond the eye. The form taken in Lake James is, therefore, in a somewhat intermediate position between *brachyurum* and *leuchtenbergianum*.

DAPHNIDAE

Daphnia arcuata Forbes, subsp. nov. **catawba**

Plate 35, figs. 1–7; plate 36, figs. 1–16

The family Daphnidae, including 6 American genera, was represented in the collections by the genera Daphnia, Ceriodaphnia, and Scapholeberis. The common Daphnia of Lake James possesses all the diagnostic characters of the genus Daphnia except that the valves do not display polygonal markings or sculptured lines of any sort, or, at most, not more than the occasional suggestion of small polygonal markings: the surface of the valves is rather closely but irregularly dotted, as with minute projections or concavities. It is of the *pulex* type, although it most nearly conforms to the diagnosis of *Daphnia arcuata* Forbes. Birge (1918)[5] says: "very probably study will show that all the *pulex* forms must be united in one polymorphic species." Meantime, he excludes from that species forms in which the head is helmeted, including *D. arcuata* Forbes.

As compared with *Daphnia pulex* (De Geer), and apart from the fact that the head is distinctly helmeted, the body of the Daphnia of Lake James is not particularly stout or heavy, nor is it very opaque. The proportions of large examples are about the same as with *pulex*, as far as can be judged from the figures of that species. In large specimens (L. 1.37 mm., not including spine) the depth of the body is nearly $\frac{2}{3}$ of the length, while small examples are commonly much more slender, the depth being about $\frac{1}{2}$ the length of shell without spine. No fixed rule governing the ratio of depth to length has been discovered, but considerable diversity in proportions is apparent. One of the smaller examples (0.86 mm.) had the greatest ratio of depth to length (ratio, 0.64), while a somewhat larger specimen (0.96 mm.) gave a depth-length ratio as low as 0.50. The proportions are doubtless in considerable degree related to brood chamber development—that is, to maturity rather than to size. Body and spine measurements and proportions of

[5] Loc. cit.

representative specimens are given in table II. This table, with plate 36 illustrate the fact that shorter examples are usually, though not invariably, more slender, and that the spine becomes not only relatively, but at last actually shorter with age.

TABLE II

Measurements and Proportions of Representative Examples of Daphnia arcuata catawba of Lake James, N. C.
(All measurements in millimeters)

NUMBER	MEASUREMENTS			RATIOS			FIGURE IN PLATE II
	Length of Valve	Length of Spine*	Depth of Valves	Spine to Length	Depth to Length	Depth to Spine	
8	0.70	0.42	0.31	0.60	0.44	0.74	a
12	0.72	0.44	0.33	0.61	0.46	0.75	
3	0.73	0.40	0.44	0.55	0.60	1.10	b
2	0.76	0.43	0.44	0.57	0.58	1.02	
9	0.78	0.40	0.38	0.50	0.49	0.95	c
5	0.86	0.46	0.55	0.54	0.64	1.19	d
16	0.87	0.40	0.46	0.46	0.53	1.15	†
11	0.88	0.47	0.45	0.53	0.51	0.94	
1	0.88	0.33	0.50	0.37	0.57	1.52	
7	0.92	0.42	0.46	0.46	0.50	1.10	e
13	0.95	0.38	0.50	0.40	0.53	1.32	
6	1.10	0.43	0.58	0.39	0.53	1.35	f
10	1.31‡	0.36	0.83	0.27	0.63	2.30	g
15	1.37	0.35	0.85	0.26	0.62	2.29	h
4	1.38	0.28§	0.81	0.20	0.59	2.89	i
14	1.40	0.31	0.83	0.22	0.59	2.68	

* For purposes of measurement, the base of the spine is regarded as being at the point of beginning of the reverse curve of posterior ventral outline of valves; assuming a line from this point perpendicular to the axis of the spine, the intersection of line and axis gives the point from which measurements are made for length of valves on the one side and length of spine on the other.

† Plate 35, fig. 1.

‡ Slightly distorted.

§ Tip of spine blunt (possibly broken ?).

With certain modifications that will be stated further on, Forbes's description of *Daphnia arcuata* (Forbes, 1893) from Heart Lake in Yellowstone Park applies closely to the Daphnias of Lake James. That description may first be quoted in full.[6]

[6] Forbes, E. A. A preliminary report of the aquatic invertebrate fauna of the Yellowstone National Park, Wyoming, and the Flathead Region of Montana. Bulletin of the United States Fish Commission 11 (1891): 207–256. 1893.

"Head helmeted, rounded in front, length one-third that of the shell, front concave, beak produced, extending beyond the sensory hairs of the antennae [antennules]. Fornices beginning above the eye and extending nearly to the middle of the back, not especially produced above the antennae. Eye small, about midway between the mandibles and the front of the head and about midway between the tip of the beak and the dorsal surface of the head. Pigment speck very small, less than half the diameter of a lens of the eye, and placed midway between the eye and the posterior margin of the head. The latter concave, the beak extending backward and applied against the margin of the shell. Swimming antennae reaching the middle of the shell, their hairs moderately robust, the first segment not longer than the second. No emargination separating head from body, but the dorsal surface very slightly sinuate there. Abdominal processes all distinct, anterior much the longest. Caudal claw with accessory teeth, about six in number, the three proximal the largest. Anal spines about ten. Posterior spine of the shell given off from the middle of the valves, in the adult female a third to a half as long as the valve. Shell moderately coarsely marked in quadrangular areas, the lower and dorsal margins spinulose from the middle backwards. Length 2 millimeters, depth 1 millimeter."

In the Daphnias of Lake James, the strongly developed teeth on the anal claw are only 3 or 4, instead of 6 (figs. 4–6), and the anal spines are slightly fewer, being about 8 instead of 10. The shell is entirely without the coarse polygonal markings, although there are occasional traces of fine polygonal areas formed by lines connecting the punctulations on the shell. The pigment spot is much nearer to the eye—about $\frac{1}{4}$ distance from eye to posterior margin of head. Some of these characters may perhaps be associated with the smaller size to which the species attains in Lake James, but the characters are so consistently displayed that I have deemed it desirable to give subspecific rank to this form. Additional descriptive notes follow:

Description of Subspecies

Characters of genus, except for lack of polygonal markings on shell.

Body not particularly stout except in largest specimens; neither distinctly opaque nor notably hyaline. Depth approximately half length of valves without spine, but variable, being greater than half in all specimens over 1 millimeter in length (and rarely in smaller examples, too), and somewhat less than $\frac{1}{2}$ length in examples less than

1 mm. Spine variable, but generally slender; about half length of valves in individuals about 0.9 mm. long, much longer in smaller examples ($\frac{3}{5}$ or more of length), and shorter in large examples (to $\frac{1}{4}$ or less of length). The spines of the largest specimens are not only relatively but also actually shorter than those of the smallest; see table II, third column. Spine arising from dorsal margin of valves in smaller examples, somewhat lower in largest: the arching of shell above the level of the spine is undoubtedly an adaptation to breeding conditions.

Valves without polygonal markings but punctate, the markings distributed with only a rough approximation to regularity; distance between points about 6μ in examples 0.82 mm. long, and about 10μ (fig. 3) in examples 1.37 mm. long. The points are due to conical formations with roughly flaring bases and with apices directed inward. Ventral and dorsal margins of valves posteriorly and spine bearing backwardly directed spinules.

No cervical sinus; rostrum long and pointed, closely applied to ventral margin of valves in stouter examples. The eye, which is removed from anterior end by a space greater than its diameter (the head being "helmeted"), has a diameter about equalling width of basal part of antenna at its middle. Pigment spot very small, closer to eye than in *arcuata*. Fornix well-developed, with slight secondary fornix or backward extension. Young may have a very minute clear spine on beak.

Posterior (dorsal) margin of postabdomen distinctly arcuate, rather evenly rounded, with 8 or 9 anal spines. Claws with conspicuous pecten of 4 teeth, possibly 5 rarely, occasionally 3 on one claw and 4 on other; pecten preceded by a series of about 8 fine hairlike spines, not described for *arcuata*; claw beyond bearing a row of fine denticles; spines, pecten and hairs arising from outer aspect of claw. Claws evenly curved, but bearing one or usually 2 spinules (not always readily distinguishable) on convex margin, the proximal about opposite proximal end of row of denticles, the distal at a distance from that equal to $\frac{1}{3}$ remainder of claw. Abdominal processes three, distinct, the anterior much the largest.

Daphnia arcuata is known from the open waters of lakes of Wyoming and Wisconsin. The subspecies here described is, as has been previously indicated (p. 232), particularly characteristic of the lake in North Carolina in which my collections were made: it was found at all stations, usually in greater abundance than any other entomostracan, and in extreme abundance at the very upper end of Catawba Lake.

Scapholeberis mucronata

Plate 34, figs. 5–8

Scapholeberis was observed in only two collections, at stations 5 and 6, both near the lower end of Catawba Lake, being more abundant in the collections made close to shore (station 5) where Daphnia was less numerous.

The members of the genus differ from species of Daphnia in the lack of a crest on the head, in the presence of a cervical sinus, and in the form of the ventral margin of the shell, which is commonly extended posteriorly by a distinct spine, the *mucro*, and marked with a prominence anteriorly. The head is rounded in front of the large eye, and extends below into a prominent beak directed downward and backward.

My examples evidently belong to the most common American species, *Scapholeberis mucronata* (O. F. Müller). The eye nearly fills the anterior portion of head. The fornix over antenna is continued downward immediately before the antenna, and another line is found passing through the eye. The antennules are very short, with anterior sense hair near the tip and several terminal hairs. The postabdomen is truncate, slightly serrate on dorsal side and with several series of hairs in successive oblique transverse lines: these may appear as a continuous longitudinal series. There are about 3 well-developed spines, besides 2 very much smaller, and 2 or 3 prominences, which are possibly the forerunners of additional spines. The claws have minute denticles, at least in the middle region.

The mucro is about $\frac{1}{4}$ length of the remainder of the ventral margin of the shell. The shell is punctate all over, and in places reticulate. The animal is relative opaque. Length of valves, 0.5–0.6 mm.

Ceriodaphnia lacustris Birge, subsp. nov. **carolinensis.**

Plate 44, figs. 5–10

It seems illustrative of the lacustrine character of the waters of Lake James that cladoceran of the very distinctive form of *Ceriodaphnia lacustris* Birge was encountered at several stations, although not in collections from the more limnetic locations. The species appear to have been recorded previously only from open waters of lakes of Wisconsin and Michigan, where it attains a length of 0.8 to 0.9 mm. (Birge, 1918). The female examples taken in Lake James are much smaller, varying in length from 0.33 to 0.49 mm., being usually about 0.4 mm. They present also deviations from the specific type form that entitle them to subspecific rank, if they are not, indeed, distinct species.

In side view the Ceriodaphnias of Lake James are strongly suggestive of species of Simocephalus, although they are much smaller. Upon direct examination, they may be distinguished by the larger eye, the want of a rostrum or downwardly directed projection of the postero-ventral margin of the head, and by the smoothly oval, rather than rhomboidal contour of the valves below the dorsal line. In dorsal view, the striking lateral expansions of the fornices over the bases of the antennae mark the species at once as of the peculiar form of *Ceriodaphnia lacustris*. Following is a description of the form taken in Lake James.

The small, downwardly-directed head has no rostrum, but the ventral contour bends upward with a distinct angle just before the antennules. There is only a slight indentation of the dorsal contour above the eye, but at half the distance from vertex to cervical sinus, the contour (in side view) may appear distinctly notched, owing to the elevation of the fornices. The head is divided from body by a deep cervical sinus. The valves are smoothly oval below, straight above with just a slight suggestion of sinuosity, and they end posteriorly at dorsal line with a blunt projection which bears two or three small spines. There are spinules along ventral margins of valves, and very fine spinules on vertex of head. The antennules are small and slender.

The anterior portion of the head is nearly filled by the large eye; the small pigment spot is slightly nearer to posterior margin of head than to eye and is somewhat elongated in a vertical direction. The antennules are short but stout, with anterior sense hair near the tip and about half a dozen terminal hairs.

The fornices over bases of antennae are highly developed, spreading out on each side as a broad triangular plate with truncate tip bearing 2 or 3 spinules; the tips are much narrower than in the species as illustrated by Birge.

The postabdomen is large, narrowing a little toward the anus, its contour forming a smooth or slightly sinuate curve before the anus and a strong smooth curve instead of an angle in the region of the anal spines. There are about 6 anal spines the second and third from the last being the largest. The anal claws are strong and without spines, but very finely denticulate.

My examples conform with Birge's description,[7] except that in the Lake James form, the eye seems to be larger, the dorsal line is not arched,

[7] Birge, E. A. Notes on Cladocera. III. Description of new and rare species. Transactions of the Wisconsin Academy of Sciences, Arts and Letters **9**: 275–317. 1893.

the tips of fornices seem narrower, and the posterior spine of the valves is not developed except as a blunt process. Birge describes the spine as "well developed and stout," and his figure in his plate XII, fig. 6 shows an entirely different outline of the valves, due to the difference in development of the spine and of the brood pouch (characters that vary with age and maturity); he also shows a narrower postabdomen than is found in my specimens.

In Lake James this form was found near shore and near the head of the Lake (Catawba), rather than in the more open waters. (See table I, p. 233.)

BOSMINIDAE

The Bosminidae are small Cladocera of particularly distinctive appearance. The contour of the highly arched back continues by a smooth curve (without cervical sinus) over the head which is prolonged into two long pointed snout-like structures. These structures, which appear as probosces, are in reality constituted of two short beaklike projections (one in Bosminopsis) of the ventral side of the head, each of which serves as a conical base for the long fixed antennules that appear as merely continuations of the conical projections from the head. The postero-ventral angle of the shell on each side is usually prolonged into a sharp spine called the *mucro*. The body is entirely enclosed within the shell, and its internal structure is relatively simple, there being no convolutions of the intestine, intestinal ceca or ocelli; abdominal processes are practically wanting. The eye is large and the antennae small. In Bosmina the dorsal ramus of each antenna has 4 joints, with setae 0-0-1-3, the ventral ramus 3 joints, with setae 1-1-3. The antennules are curved and "jointed," and have quite inconspicuous sensory hairs on the side near the base with a small triangular plate above them; the "jointed" appearance of the antennules is most noticeable on the anterior side; the posterior side may appear quite smooth.

Bosminas occurred in nearly every collection, but were found abundantly only in open waters of Paddy's Creek Lake just above its connection with Catawba Lake: at this place Bosminas were second in abundance to Diaptomus.

Bosmina longispina Leydig

Plate 37, figs. 6–10

This species occurred at stations 1, 5, 11, 12, 13 and 15, but was most abundant at station 15, where examples were found in lengths from 0.28 to 0.48 mm.

The mucro is long, about $\frac{1}{4}$ length of valves without mucro, and conspicuously barbed on dorsal side (figs. 6–9). Striate markings are distinguishable on the shell, being especially distinct on the head. The postabdomen is truncate with anal opening at the end. The slender anal claws bear a series of about 6 large denticles at the base, the remainder of the claw being smooth (fig. 10).

Bosmina longirostris (O. F. Müller)

Plate 37, figs. 1–5

At station 15, particularly, a form was found represented by specimens of lengths from 0.25 to 0.37 mm., and differing from the preceding species in several characters. Mr. Chancey Juday has kindly examined examples of this form and supplied the identification, at the same time confirming the identification of the preceding species.

While in *longispina*, as observed, the mucro was evidently barbed and invariably a little less than $\frac{1}{4}$ length of valves, in the other form the mucro was smooth, or nearly so, and relatively short, varying in length from $\frac{1}{10}$ to $\frac{1}{6}$ the length of valves, and having the *greatest relative length in the largest examples;* in all except the smallest the mucro was longer than the anal claw and the process bearing it. To make further comparisons with *longispina*: the antennules are shorter, the striations of the shell less noticeable, the head is somewhat larger and more opaque, and the shell is less translucent.

I am not sure that all of the Bosminas observed are referable to these two species. There is considerable diversity particularly among the specimens provisionally referred to the species *longirostris*, and it may be that more extended study would reveal the presence of another species, as *obtusirostris*. It would be useless to go further without an intensive study of the changes of form and proportions with age and the variations in combinations of characters difficult to distinguish and to define. Birge has commented upon the fact that the genus is difficult and has received little attention in America. It offers an opportunity for research.

CHYDORIDAE

Chydorus sphaericus (O. F. Müller)

Plate 34, fig. 9

A small chydorid in collections made at stations 11 and 15, near the upper end of Catawba Lake, was identified with this species, character-

ized by Birge as: "The commonest of all Cladocerans; found all over the world." Following are descriptive notes based upon our specimens.

The shell is ovoid-elliptical, with long smooth dorsal contour not greatly arched, and with rounded posterior, infero-posteal and ventral angles: thus, in side view the upper part of the shell represents the half of an ellipse and the lower part the half of a hexagon with rounded angles. The margins of the valves are entirely smooth. The posterior margin is hardly more than $\frac{1}{3}$ of greatest depth of valves, and the greatest depth is about $\frac{3}{4}$ of the length. The valves are without striations, but are punctate and some have polygonal markings.

Fornices abruptly narrow into rostrum to form a long and acute beak projecting ventrally in front of antennules, there being a very broad rounded angle between anterior margin of valve and beak.

The antennae are small, with both rami 3-jointed; the antennules are stout and blunt, not projecting over halfway from ocellus to tip of beak, but the setae may extend a little beyond beak.

Eye and ocellus are well developed, ocellus about equalling eye and placed at about $\frac{2}{5}$ of distance from eye to tip of beak. The keel of the labrum is smooth, but with greater or less concavity on anterior margin; when the concavity is distinct as in the example represented by figure 9, the keel is somewhat pointed ventrally.

The intestine is convoluted. The anus opens on dorsal side about midway between insertion of abdominal setae and end of postabdomen, and there is a marked pre-anal angle. Beyond anus the postabdomen bears a series of about 8 marginal denticles, and at the tip a claw with one spine at its base. The postabdomen is short, its length from abdominal setae to base of claw being about 3 times its width at anus; it is truncate and the "apex" is rounded, not prolonged or prominent; the dorsal (anal) margin is rather sinuate, the ventral margin nearly straight but slightly concave.

I am indebted to Mr. Chancey Juday for confirmation of the identification of examples of this species.

COPEPODA

CENTROPAGIDAE

Diaptomus birgei Marsh

Plate 38, figs. 2 and 3; plate 39, figs. 1–10

Considering both size and numbers, the most conspicuous element of the plankton of Lake James is *Diaptomus birgei* Marsh. This large

stout copepod distinguishes itself from all others in the lake by its long heavy trunk (cephalothorax), its small tail (abdomen) ending in a pair of short fans of curved setae (in lieu of the long slender trailing setae of Cyclops and Canthocamptus), the very long antennae exceeding the body in length, and its single egg sac (as compared with the paired egg sacs of Cyclops). Many of the females without egg sacs are conspicuously marked by the spermatophores (pl. 38, fig. 2, and pl. 39, figs. 1 and 2), of which one, two or three may be suspended from the base of the abdomen.

Evidently Diaptomus is economically, as well as ecologically, the most important element of the zooplankton of the lake. The introductory statements of March[8] in his monograph on this genus (1907, p. 381) seem to be as applicable to this case as to any:

"The genus Diaptomus is of special interest to the student of plankton because, in so many cases it forms the major portion of that part of the plankton which is available as food for fishes. It is true that in plankton-rich bodies of water, the largest collections consist, for the most part, of vegetable material, but a large proportion of the vegetable material is waste so far as concerns its serving directly as food for animals. It is true, too, that in some cases other Copepoda or Cladocera may form the bulk of the animal part of the plankton, but commonly it is Diaptomus that is most prominent."

It may be said that at few of our stations in Catawba or Paddy's Creek Lake did the net-catches of plankton, even with fine net, show a proportion of vegetable material equalling that of animal material (Entomostraca). Although Diaptomus is dominant at one of our richest stations, No. 13, yet both Daphnia and Diaphanosoma exceed it in numbers at the richest station of all, No. 12, and Daphnia was apparently more generally distributed in the lake. But even though Daphnia may be the most numerous entomostracan of the lakes, it is possible that Diaptomus may be the predominant form in bulk. Catches based upon a few collections can, of course, be suggestive only.

The occurrence of *Diaptomus birgei* in the lakes has an aspect of interest from the standpoint of geographic distribution. Marsh, who has made the most extensive and careful study of the genus, emphasizes the fact that the species of Diaptomus are generally of limited distribution (1907, p. 381).

[8] Marsh, C. Dwight. A revision of the North American species of Diaptomus. Transactions of the Wisconsin Academy of Sciences, Arts and Letters **15**: 381–516. 1907.

"Most of the species of Cyclops in America are identical with those of other continents, but this is true of none of the species of Diaptomus. All of our species are peculiar to this continent, and some of them have a habitat of relatively narrow limits. It would appear that Diaptomus is quite susceptible to the influences of its environment, and this fact makes the study of the genus of peculiar interest."

At the time of his writing, and up to the present time, *D. birgei* was known only from Wisconsin, Indiana, and Long Island, and Marsh, who regarded temperature and ease of water communication as the primary factors governing the distribution of Diaptomus, thought that *D. birgei* probably did not occur south of the Ohio River. Again, he says, "*D. siciloides* and *D. birgei* are probably limited, speaking in a very general way, to the region between the parallels of 39° and 43°. The distribution with reference to latitude is very marked in the case of most members of this group" (the *tenuicaudatus* group of Diaptomi). The lakes of Western North Carolina, at about latitude 36°, fall well without the supposed range of the species. At first it suggested itself as a possible explanation of the seeming anomaly of distribution that the species had been introduced into the lake with cans of young fish brought from more northern waters and planted in the lake, and that it had found at that altitude conditions of temperature corresponding closely enough to those of its accustomed habitat. Subsequently, however, the species was found to be one of two entomostracan forms that comprised a very rich plankton in the city reservoir of Durham, N. C., December 12, 1923. Probably then, *Diaptomus birgei* is one of the common indigenous copepods of North Carolina waters, and the extent of its range has been unknown for lack of sufficient collections in waters of southeastern states. Dr. Marsh has very kindly examined specimens from Lake James and confirmed the identification:

Diaptomus birgei is a very readily identifiable species, for its "diagnostic" features are easily observable, providing males are at hand. The slight blunt protuberance at the upper end of the ante-penultimate segment of the right antenna of the male (pl. 39, fig. 4), in lieu of a distinct appendage, long process or lamella; the length of the left fifth foot of the male (fig. 5) which extends to or barely beyond the base of the last joint of the right; the distinctly bent hooks on last segment of the right exopodite; the quadrangular hyaline appendage on the basal joint of right exopodite: these characters seem to be combined by no other species. I do not, however, observe the abdomen of the female to be as described and figured by Marsh. Instead of the second segment

being "very short and nearly concealed by the first, the second segment in mature females of these collections is about as long as the first and bears on its ventral surface a strong and slightly hooked process. The articulation between the two segments, which is just anterior to the hook and just posterior to the point of attachment of the spermatophores, is not conspicuous. The difference might be due to variations with age, season or locality. It was observed with reference to specimens taken in the Durham reservoir in December, 1923, that the penultimate segment of the abdomen of immature females was relatively short, although never nearly so short as was found by Marsh. Figures 7 to 10 of plate 39 give an indication of the ontogenetic history of the abdomen of females, involving a reduction in the number of segments, changes in relative lengths of segments, and the acquirement of a double bend in the abdomen as a whole. The distinctive form of the abdomen in the male may be observed by comparing fig. 11 with fig. 9 or with figs. 1 and 2.

The hook on the ventral side of the second segment of mature females has somewhat the appearance of a short bent thumb, and is a conspicuous feature.

The spermatophores are long spindle-shaped bodies, almost identical in form with those of *Diaptomus gracilis* of Europe, as described and illustrated by Gruber (1878),[9] the sperm cells within are also of the same oval form as in *gracilis*.

The specimens from Lake James are larger than those previously described, the females averaging 1.5 mm. in length exclusive of caudal setae (1.3 to 1.6 mm.), and males about 1.3 mm. The measurements given by Marsh are, for females 1.31 and for males 1.22. The species was most abundant at stations 12 and 13 at the very upper end of Catawba Lake, and very numerous in the upper part of Paddy's Creek Lake. It was found at all stations but one (station 10).

CYCLOPIDAE

The genus Cyclops is represented in the collections by 3 species, all of very broad geographic distribution: *leuckharti*, *serrulatus* and *prasinus*.

Cyclops leuckharti Claus

Plate 40, figs. 5, 6, and 7

Widely distributed in the lakes and the only Cyclops that anywhere approaches to Diaptomus in abundance, is this lacustrine species. It is

[9] Gruber, August: Über zwie Süsswasser-Calaniden. Leipzig, 1878, pp. 1–34.

the only representative of the family forming a characteristic feature of the fauna of the these waters. In the upper part of Paddy's Creek Lake it constituted about 6 per cent of the entomostracan fauna, as compared with 38 per cent for Diaptomus; while at station 12 in the upper part of Catawba Lake it constituted 14 per cent as compared with 24 per cent for Diaptomus; see also table I, p. 233. Most of the specimens were about 1 mm. in length excluding setae and were not of mature form; the small number of specimens with full number of segments of antennae (17) was notable: these measured about 1.3 mm. in length. None were found with egg sacs. No significant deviations from published descriptions were observed, but in some instances there was detected an exceedingly fine ciliation on the inner margins of furcal rami, as illustrated on the left ramus in fig. 6; previous reference to such a character has not been found. Attention may be called to the relative length and flexibility of the caudal setae, which are very finely barbed and contrast strongly with the corresponding setae of *Cyclops serrulatus* (fig. 3), a species of less limnetic habit. The species is of worldwide distribution. Marsh (1910) quotes Annandale as reporting that in India, this species is found not only in fresh but in brackish ponds as well.

Cyclops serrulatus Fischer

Plate 40, figs. 3 and 4

This copepod, also of worldwide distribution, and common in pools and aquaria, was observed only in the extreme upper end of Catawba Lake, where it constituted less than 4 per cent of the adult entomostracan population. The individuals were relatively small, but, among copepods, *Cyclops serrulatus* is unusually variable as to size: females with egg sacs measured about 0.53 mm. in length. The form collected is apparently intermediate between the limnetic variety *elegans* and the litoral variety *montanus*.

Cyclops prasinus Fischer

Plate 40, figs. 1, 2 and 8

This species was identified only from station 11, a limnetic region although not far from the upper end of Catawba Lake. Only females were seen, some being with egg sacs; a representative example measured had a length of 0.58 mm. The species, according to Marsh (1918) is

widely distributed, especially in the larger bodies of water, being common in the Great Lakes. Its occurrence in Lake James, a lake of moderate size, but of very recent formation by artificial means, seems of special interest.

Its long antennae, extending to the base of the abdomen, but composed of only 12 segments, the resemblance of its fifth feet (fig. 8) to those of *serrulatus* (fig. 4), and the similarity of its caudal furca (fig. 2) to those of *leuckharti* (fig. 6), make the species unmistakable when with egg sacs and therefore of known sexual maturity. The characteristic outward curve of the outer part of the antenna has been commented on by Marsh.[10] Spaeth[10] has directed attention to the apparently general occurrence of a sensory hair on the 10th segment of the antenna of American forms, instead of a sensory club on the 9th segment as described for *Cyclops prasinus* in Europe. A hyaline plate was not observed on last segments of antennae.

HARPACTIDAE

In collections from the lagoonlike waters at the upper end of Catawba Lake (station 13) minute females of a species of Copepod resembling Canthocamptus were common, although the season, late summer, is supposed to be a most unfavorable time for collecting harpactid copepods. The two collections made at this station, and they were relatively heavy plankton catches, comprised probably several hundred females of this species with or without egg sacs. Careful search for males was made, but only two male harpactids were discovered in the collections at station 13, and not a single harpactid of any kind in collections made at any other station.

Since but one form of female and but one form of male were found at the same place, it might have been thought that we had to do with a single species, but that the males, though small, were much larger than the egg-bearing females, which is contrary to the general condition among copepods. The length of body, antennae and setae excluded, is for females of our collection 0.43 mm. and for males 0.64 mm. The males were, then, about 50 per cent longer than the females, with

[10] Marsh, C. Dwight. A revision of the North American species of Cyclops. Transactions of the Wisconsin Academy of Sciences, Arts and Letters **16**, pt. II: 1067–1135, pls. 72–81. 1910.

Spaeth, Reynold A. The distribution of the genus Cyclops in the vicinity of Haverford, Pennsylvania. Proceedings of the Academy of Natural Sciences of Philadelphia, LXVI, p. 20–63, 1914.

other proportions in correspondence. No females were observed that approximated the size of the males. In addition to sex characters, there are to be noted differentiating structural characters of possible specific value. In the circumstances, we do not feel justified in assigning the two forms to the same species and thus assuming an inversion of the common rule of sex differences in size.

The female harpactids (pl. 38, fig. 1) from station 13 in Lake James are among the smallest of known copepods (length of body 0.43 mm.). They belong to the section designated by Sars[11] as Chirognatha, having the (posterior) maxillipeds (pl. 44, fig. 4) "pronouncedly prehensile, terminating in a more or less powerful clawed hand." Within this section they are clearly affiliated with the Canthocamptidae, having the single ovisac, a slightly developed rostrum, very small outer ramus of second antenna, the first legs "prehensile" in type, with inner ramus longer than the outer.

Our form differs from species of the genus Canthocamptus, as defined by Sars, in that the inner rami of the second and third legs are 2-segmented, rather than 3-segmented. Sars recognizes the validity of the genus Attheyella to include species much like Canthocamptus but in which the inner rami of the second, third and fourth legs are poorly developed and composed of 2 segments, the basal one being very short; the first legs less "prehensile" in form than in Canthocamptus, with inner ramus 2-jointed (or less often, 3-jointed) and not much longer than the outer ramus. Our specimens clearly belong in this group. They seem closely related to *Attheyella crassa* Sars, which they resemble in general form and particularly in the high development of the fringes of long spinules on the lateral and ventral margins of abdominal segments. Not only, however, are they decidedly smaller in size, but they seem to be excluded from that species by several distinct characters. The caudal furca, although suggestive of those of *crassa*, are not so widely divergent, and in dorsal aspect are distinctly oblong and not pyriform; the apical setae are not twisted; the anal opercle is not smooth but finely spinose; the fifth legs also differ noticeably from those of *A. crassa*, in that the inner expansion is not elongated or "linguiform" to extend beyond middle of distal segment, but is relatively low

[11] Sars, G. O. An account of the Crustacea of Norway. V. Copopoda-Harpacticoida. Bergen Museum. 1911.

Sars regards as synonymous *Canthocamptus crassa* Sars, *Attheyella spinosa* Brady, and *Paratachidius inermis* Brady. The species has been recorded from Norway, Sweden, British Isles, Holland and Germany.

and broad and bears 4 marginal setae, rather than 6. The hooked keel on dorsal side of furca is not shown for *crassa*, by Sars or by Schmeil.[12] I have assigned to this form the name *Attheyella caroliniana* n. sp.

Delachaux[13] has recently described from the high Andes of Peru (above 5000 meters) a copepod (*Canthocamptus godeti*) with some of the striking features of our form, notably the hooked keel on dorsal side of furca and the spination and sculpture of the abdominal segments. Our species is, however, readily distinguished from *C. godeti* by the much shorter inner expansions of basal joints of fifth feet, by the spinous anal opercle, and by the lack of the thornlike spines on the postero-ventral margin of the last abdominal segment. Apparently *Canthocamptus* (*Attheyella*) *godeti* is closer to the form of *crassa* than is *caroliniana*.

Turning now to consideration of the two male examples, we find that the form is clearly distinguished from the genus Canthocamptus by the bi-articulate character of the inner rami of the swimming legs, and that the legs are much better developed than in species of the genus Moraria. In some details the form strikingly resembles species of Nitochra—mouthparts, and form of fifth feet and of caudal furca; it differentiates itself from that group, however, by the structure of the second and third swimming legs, with their 2-jointed inner rami. The genus Mesochra, as defined by Sars, is distinguished from Canthocamptus "in the reduced number of articulations in the anterior antennae, and in the more pronounced prehensile character of the first pair of legs, and also in the inner ramus of the natatory legs being bi-articulate, with the proximal joint well developed." The first of these characters can not be determined from male specimens alone; the second and third apply well; but the fourth is doubtful. No freshwater forms are yet known in that genus.

Our specimens conform with the genus Attheyella in practically all characters (so far as can be determined from males alone), but the inner ramus of the first leg is relatively much longer than is usual in that genus and the modification of the inner rami of the third legs is extreme. While I cannot relate these specimens closely to any known species, I believe that they fall within that genus. Disregarding common sex characters, they differ from the females taken at the same station in the absence of the conspicuous bristly appearance of the posterior seg-

[12] Schmeil, Otto. Deutschlands freilebende Süsswasser Copepoden. 2 Teil. Harpacticidae. Bibliotheca Zoologica 15. 1893.

[13] Delachaux, Theodor. Neue süsswasser Harpactiden aus Südamerika. Zoologische Anzeiger **49**: 315–335. 1918.

ments, in the form and spination of the furca, and in the much greater length of the inner rami of the first legs: plate 42, fig. 1 may be compared with plate 43, fig. 3. Nevertheless, it is not impossible that they are of the same species. Descriptions of the two forms follow.

Attheyella caroliniana n. sp.

Plate 38, fig. 1; plate 43; plate 44, figs. 1–4

The rounded tapering body is markedly sway-backed, the posterior portion of the body frequently forming a right angle with the anterior half (in preservative). Although very small, even for harpactids, the animal has a relatively broad "stocky" appearance which is enhanced by the flouncelike fringes of spreading spines on the second to fourth abdominal segments. Other striking characters are the high development of setae and spines on appendages and the sharply sculptured posterior outlines of all segments. The greatest depth is about $\frac{1}{4}$ of length, which is about 0.43 mm.

The suture between the first and second segments of the abdomen is not always completely obliterated; the second to fourth segments bear each a ring of long, slender out-flaring spinules, the rings not complete above and placed near posterior margin. The branches of caudal furca are little longer than wide, markedly constricted at base but with squarish distal end (in dorsal or ventral view). The larger caudal seta is stout, strongly plumose, and distinctly exceeds the length of the abdomen; it is sometimes nearly as long as the entire body; in some cases the barbs of the inner side are more closely spaced than those on the outer side. Just inward of the base of the larger seta there is a third terminal seta or hair, relatively short, slender, curved, and not evidently plumose.

The armature of the furca is very constant. In addition to the three terminal spines (or 2 setae and one hair), there are a dorsal, a lateral, and 2 ventral spines, and a large dorsal hook, beneath and behind which there is a comb of 6–8 curved spinules (pl. 43, figs. 8 and 9). The last abdominal segment ends without spines, but bears a dorsal anal plate with spinate margin, the spines being simple.

Both branches of the first legs are 3-jointed, the inner ramus being a little longer than the outer; inner branches of second, third, and fourth legs are 2-jointed, the basal joint being very short. The arrangement of setae, spines and hairs are shown in figs. 3–6, pl. 43. The basal portion of the fifth foot is rather small, the mesial extension bearing 4 plu-

mose setae in step-like series; the outer distal angle of the segment supports a long seta. The outer joint is relatively elongate, not ovate, with 2 terminal setae, the inner the longer, a seta and 2 short spines on the inner side and 2 relatively short and stout setae and 2 spines on the outer side.

The anterior antenna comprises 8 or 9 segments, for it appears very clear that in some cases a joint occurs just at the origin of the row of 3 hairs on the eighth joint, leaving a short ninth segment bearing only terminal setae. The basal joint bears several stiff hairs and an anterior terminal seta; the second joint has 3 short hairs, one particularly slender, and 4 long hairs, 2 being on the ventral side, and one of the hairs may be setose or not; the third joint has 3 short and 2 long hairs, one from the side and one terminal; the fourth joint is extended by a process that bears the sensory club with trigger-like termination and a slender hair, the absolute and relative lengths of hair and club being variable; the short fifth joint bears a single long hair, the sixth 2 shorter hairs, and the seventh a long terminal hair and a shorter lateral hair; the eighth (or basal portion of the last joint) bears one lateral and 3 terminal (?) hairs, and, finally, the tip of the antenna (ninth joint or distal portion of eighth bears 2 long slender hairs and a shorter one with rather blunt tip. Although many specimens have been examined, I have never found the least evidence that any of the antennal hairs were setose, except, invariably, the terminal hair of basal joint, and, not invariably, one of the hairs on second joint.

The antennules (pl. 43, fig. 2) have a very small inner ramus of one segment with 4 short setae, 2 terminal and 2 lateral; the outer ramus bears a number of hairs and spines and 3 long terminal setae with the usual appearance of articulations at about half their length. The mouth parts, which are illustrated in plate 44, figs. 1 to 4, are very minute and difficult of dissection, but they seem to present no notably distinctive characters.

Distinguishing characters of the species are the strongly spinose margins of abdominal segments; the segmentation of the appendages —3/3, 2/3, 2/3, 2/3, 2; the form and spination of the caudal furca; and the form of the 5th feet.

Taken in plankton net, hauled near surface in shallow water near head of Catawba Lake division of Lake James, North Carolina, near end of August, 1922. Males unknown.

Attheyella sp.?

(Description of male specimens)

Plates 41 and 42

The distinctly rounded and somewhat sway-backed body tapers gradually from the head to the last abdominal segment, which is about ½ the greatest diameter of the body. The greatest depth is about ⅓ of length, giving the body a very robust appearance. The rostrum is well-developed and triangular with acute anterior point (pl. 42, fig. 8). Setae and spines on appendages are highly developed. The second to fifth abdominal segments bear each a row of spinules at the posterior ventral margin; there are also a few spinules on the sides of the last thoracic and the first abdominal segments. The last abdominal segment is deeply notched, almost completely divided.

The length and width of the branches of the caudal furca are approximately equal; each branch has 2 terminal setae and, just inward of the larger seta, a short slender curved hair about equal to length of furca.

The segmentation of the modified antennae is difficult to make out with certainty, but apparently there are 8 segments, the 3rd and 7th being very small; the 6th bears a strong hooklike spine. The posterior antennae or antennules, have an undivided basal portion and a very small inner ramus; the usual appearance of articulations in the middle of each of 3 of the terminal setae may be noted.

Both branches of the first legs are 3-jointed, the inner ramus being very strongly developed with its basal segment as long as the entire outer ramus. The inner branches of the 2nd, 3rd and 4th legs are 2-jointed, the basal joint being very small,—less markedly so in the 2nd. The 3rd leg is strongly modified, the 3rd segment being elongate, truncate, and terminating in 2 long setae, and the 2nd (middle) segment extended laterally by a strong process which is curved downward and more than twice as long as the 3rd segment; this process is doubly barbed at the tip.[14] Features of this spination of the appendages are the ciliate margins of the stouter spines and the variable aspect of the barbs on the longer setae, which may be relatively close-set and straight, or sparser, long, slender and, apparently flexible; the 4th legs (pl. 42, fig. 4) illustrate the several forms of barbs, and it may there be noted that certain

[14] Two barbs (though much stronger) are shown by Delachaux at tip of corresponding process in *C. godeti*.

setae have short close-set barbs on one side and slender sparser barbs on the other. Two spines on the first leg have hairlike appendages near the tip; they are suggestive of the sensory structures of antennae, although I have not seen references to specialize sensory organs on the swimming feet of copepods.

The basal segments of the fifth pair of legs are confluent in the middle line, and the low mesial expansion on each side bear 3 strong but short spines; the external distal angle evidently bears a well-developed seta, but these were broken off in my specimens. The 2nd segment is small and ovate, with 5 main spines, the second from within being much the strongest and the middle one slender and hairlike; there are also several small spines on the inner and outer margins of this segment.

Distinguishing characters of this form are: the robustness of the body; the segmentation of the appendages—3/3, 2/3, 2/3, 2/3, 2; the great development of the inner ramus of the 1st legs; the strong modification of the 3rd legs; and the form of the 5th legs.

Two male examples taken in plankton net, hauled near surface in shallow water near head of Catawba Lake division of Lake James, North Carolina, near end of August, 1922. Females unknown.

SUMMARY

There is described an artificial lake system at the foot of the mountains in western North Carolina, with some comments on the occurrence of Copepods and Cladocera in a limited series of collections of surface plankton.

The predominant copepod is *Diaptomus birgei* Marsh, its occurrence in these collections representing a marked extension of the known range of a supposedly northern species. Three species of Cyclops were noted, all being of broad distribution. A new species of harpactid was found belonging to a genus, Attheyella, that has not previously been recorded from the freshwaters of North America. The species is fully illustrated. Two male harpactids of the same or a related species are described and illustrated.

Seven species of Cladocera are reported, including a new subspecies of *Daphnia arcuata* Forbes (subspecies *catawba*), the species having been known hitherto only from waters of Wyoming and Wisconsin, and a new subspecies of *Ceriodaphnia lacustris* Birge (subspecies *carolinensis*), a species known from lakes of Wisconsin and Michigan. Variations of form in *Daphnia arcuata catawba* are noted and illustrated.

UNIVERSITY OF NORTH CAROLINA,
CHAPEL HILL, N. C.

EXPLANATION OF PLATES

PLATE 34

Fig. 1. Diaphanosoma brachyurum: Anal claw. × 480.
Fig. 2. Diaphanosoma brachyurum: Postabdomen. × 312.
Fig. 3. Diaphanosoma brachyurum: Dorsal aspect with valves closed. × 43.
Fig. 4. Diaphanosoma brachyurum: Dorsal aspect with valves outspread. × 28.
Fig. 5. Scapholeberis mucronata: Head with antennule and labrum. × 180.
Fig. 6. Scapholeberis mucronata: Postabdomen. × 180.
Fig. 7. Scapholeberis mucronata: Ventral aspect. × 70.
Fig. 8. Scapholeberis mucronata: Lateral aspect. × 70.
Fig. 9. Chydorus sphaericus. × 180.

PLATE 35

Daphnia arcuata catawba

Fig. 1. Side view of example 0.87 mm. long, not including spine. × 60.
Fig. 2. Dorsal view of shell. × 60.
Fig. 3. Markings on shell of individual 1.37 mm. long. Aspect when focusing (up) on bases of conical structures shown below line; aspect when focusing down shown above line. × 600.
Fig. 4. Left claw of individual 1.04 mm. long. × 600.
Fig. 5. Right claw of same. × 600.
Fig. 6. Postabdomen of example 0.82 mm. long. × 375.
Fig. 7. Abdominal processes of individual 1.37 mm. long. × 83.

PLATE 36

Outlines of 16 examples of *Daphnia arcuata catawba*, to show diversity in proportions: Valves (without spine) generally, but not invariably, deeper in longer examples; spine shorter in largest examples than in smaller. See table II, p. 237. All × 46.

PLATE 37

Figs. 1–5. Illustrating variations of form in *Bosmina longirostris;* L. 0.28–0.48 mm. × 70.
Figs. 6–8. Illustrating variations of form in *Bosmina longispina;* L. 0.25–0.37 mm. × 70.
Fig. 9. *Bosmina longispina* Leydig; young. × 180.
Fig. 10. Postabdomen of *Bosmina longispina*. × 300.

PLATE 38

Fig. 1. Attheyella caroliniana: female with egg sac (L. 0.43 mm.). × 181.
Fig. 2. Diaptomus birgei: female with egg sac, side view (L. 1.36 mm.). × 69.
Fig. 3. Diaptomus birgei: female with spermatophore (L. 1.48 mm.). × 69.

PLATE 39

Fig. 1. Diaptomus birgei, female: abdomen and last thoracic segments with spermatophore.
Fig. 2. Do., with 3 spermatophores.
Fig. 3. Diaptomus birgei, female: fifth thoracic feet.
Fig. 4. Diaptomus birgei, male: right antenna.
Fig. 5. Diaptomus birgei, male: fifth feet.
Fig. 6. Diaptomus birgei, male: end of left fifth foot.
Fig. 7. Diaptomus birgei: abdomen of immature female, with 4 segments, dorsal view.
Fig. 8. Diaptomus birgei: abdomen of immature female, with 3 segments, side view.
Fig. 9. Diaptomus birgei: abdomen of mature female, with 3 segments, second being long.
Fig. 10. Diaptomus birgei: same, dorsal view.
Fig. 11. Diaptomus birgei: abdomen of male.
Figs. 7 to 11 made from examples from Durham, N. C., reservoir; all other figures from specimens taken in Lake James, N. C. All figs. × 67.

PLATE 40

Fig. 1. Cyclops prasinus: Antenna of female (distortion due to mounting obscures the natural and characteristic outward curve of the distal portion of the antennae).
Fig. 2. Cyclops prasinus: Caudal furca.
Fig. 3. Cyclops serrulatus, female: Caudal furca.
Fig. 4. Cyclops serrulatus, female: Fifth foot.
Fig. 5. Cyclops leuckharti: Tip of antenna.
Fig. 6. Cyclops leuckharti: Caudal furca (compressed).
Fig. 7. Cyclops leuckharti: Fifth foot.
Fig. 8. Cyclops prasinus: Fifth foot, highly magnified.
Fig. 8 × 920; all others × 300.

PLATE 41

Attheyella—sp. incert. male

Fig. 1. Side view of male (length 0.64 mm.), from Lake James.
Fig. 2. Anterior antenna; and, fig. 2a, side view of 5th, 6th, and 7th joints.
Fig. 3. Posterior antenna.
Fig. 4. Labrum.
Fig. 5. Mouthparts in position, with base of first pair of legs (not for details of mouthparts).
Fig. 6. Mandible.
Fig. 7. Maxilleped.
Fig. 8. Rostrum, with basal points of antennae.
Fig. 1 × 90; fig. 5 × 230; all others × 380.

PLATE 42

Attheyella—sp. incert.

Fig. 1. First foot. × 230.
Fig. 2. Second foot. × 230.
Fig. 3. Third foot. × 230. Also detail of tip of dactyl of chela of inner ramus. × 600.
Fig. 4. Fourth foot. × 230.
Fig. 5. Distal segment of fifth foot, drawn to same scale as the other appendages. × 230.
Fig. 6. Fifth pair of feet (more highly magnified). × 380.
Fig. 7. Inner ramus (Chela) of third leg. × 380.
Fig. 8. Portion of genital plate.
Fig. 9. End of abdomen, lateral aspect. × 380.
Fig. 10. End of abdomen, ventral aspect. × 380.

PLATE 43

Attheyella caroliniana, female

Fig. 1. Anterior antenna.
Fig. 2. Posterior antenna.
Fig. 3. First leg.
Fig. 4. Second leg.
Fig. 5. Third leg.
Fig. 6. Fourth leg.
Fig. 7. Fifth leg.
Fig. 8. End of abdomen, dorsal aspect.
Fig. 9. End of abdomen, ventral aspect.
Fig. 10. Egg sac.
Fig. 10 × 72; all others × 304.

PLATE 44

Fig. 1. Attheyella caroliniana, n. sp.: mandible.
Fig. 2. Attheyella caroliniana, n. sp.: 1st maxilla (maxillula).
Fig. 3. Attheyella caroliniana, n. sp.: 2nd maxilla (maxilla).
Fig. 4. Attheyella caroliniana, n. sp.: maxilliped.
Fig. 5. Ceriodaphnia lacustris, subsp. carolinensis; head.
Fig. 6. Ceriodaphnia lacustris, subsp. carolinensis; side view.
Fig. 7. Ceriodaphnia lacustris, subsp. carolinensis; side view.
Fig. 8. Ceriodaphnia lacustris, subsp. carolinensis; postabdomen. (Fine denticulations of anal claw can not be shown).
Fig. 9. Ceriodaphnia lacustris, subsp. carolinensis; ventral aspect.
Fig. 10. Ceriodaphnia lacustris, subsp. carolinensis; dorsal aspect.
Figs. 1–4 × 600; figs. 5–7, 10 × 88; fig. 8 × 375.

PLATE 34

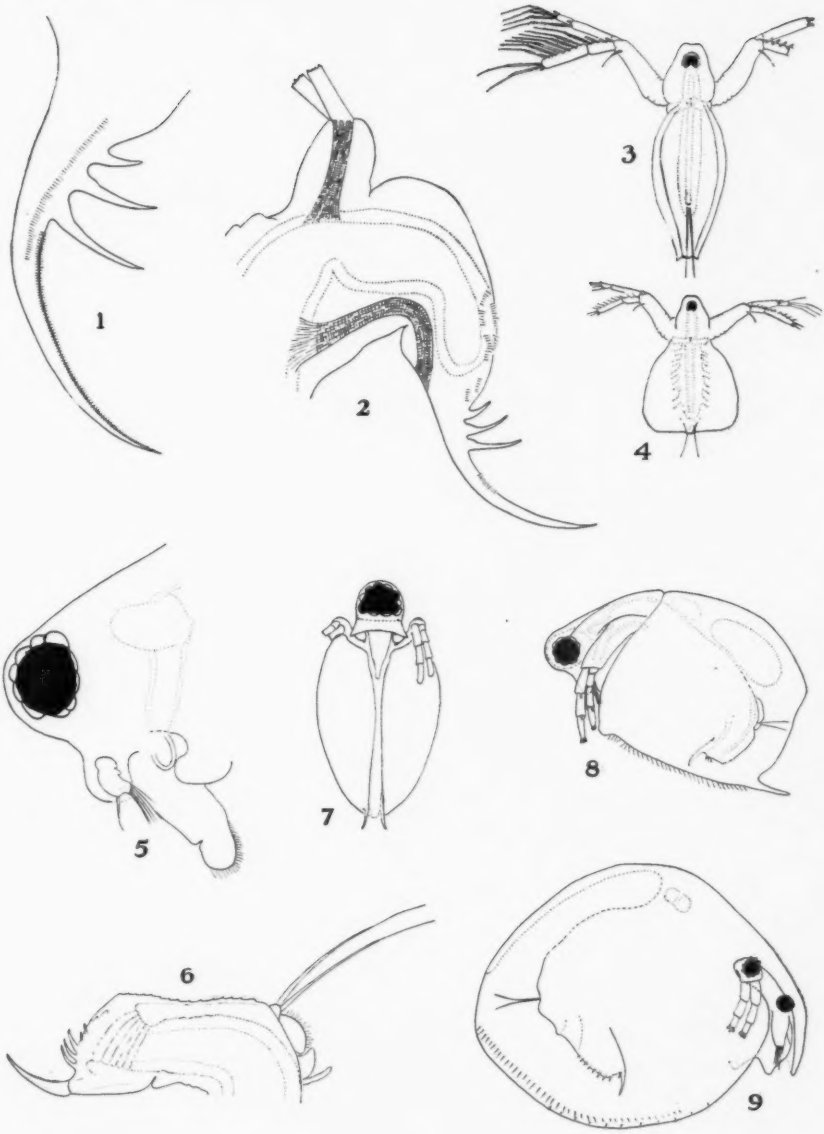


PLATE 35

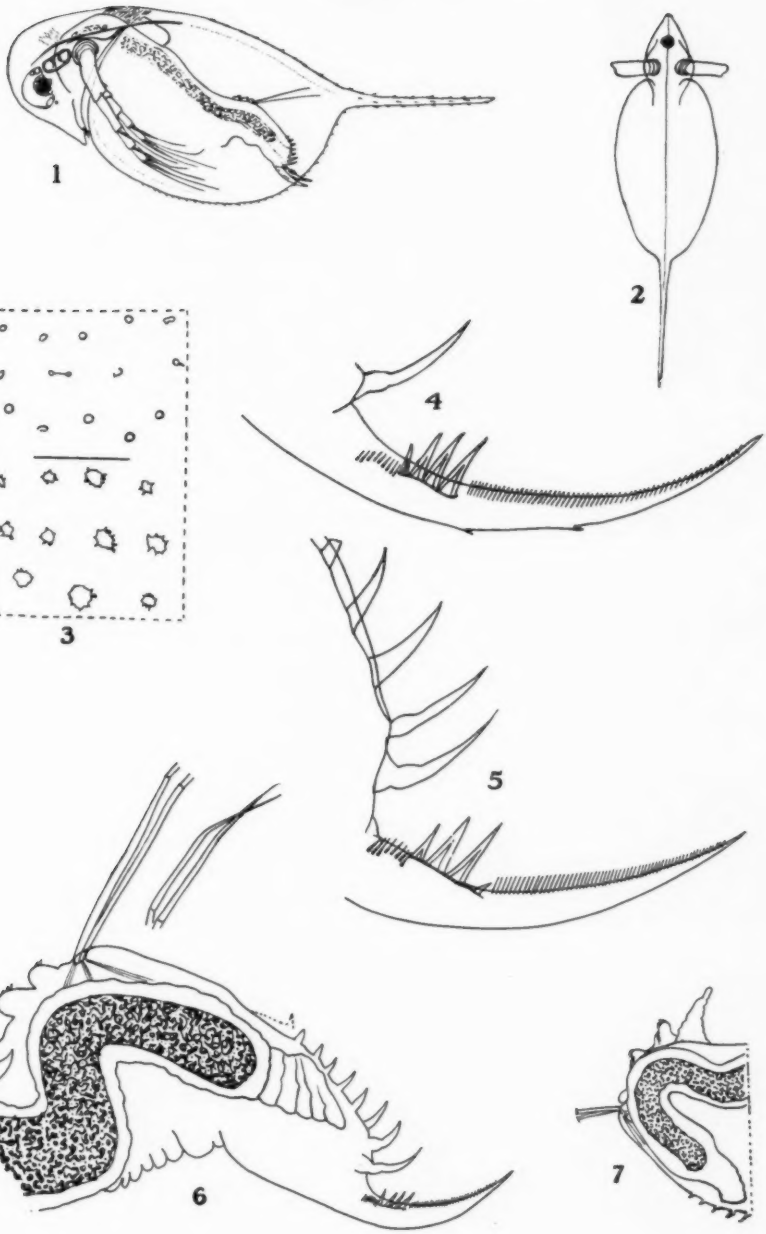


PLATE 36

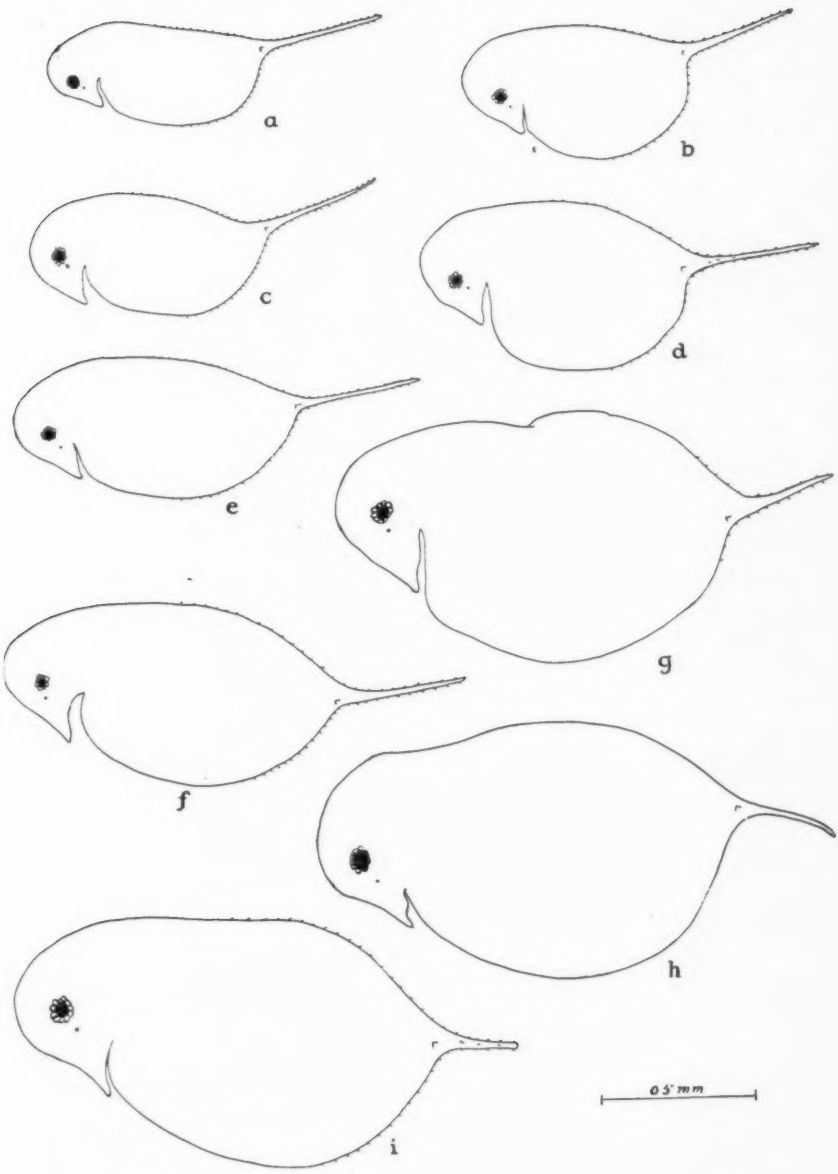


PLATE 37

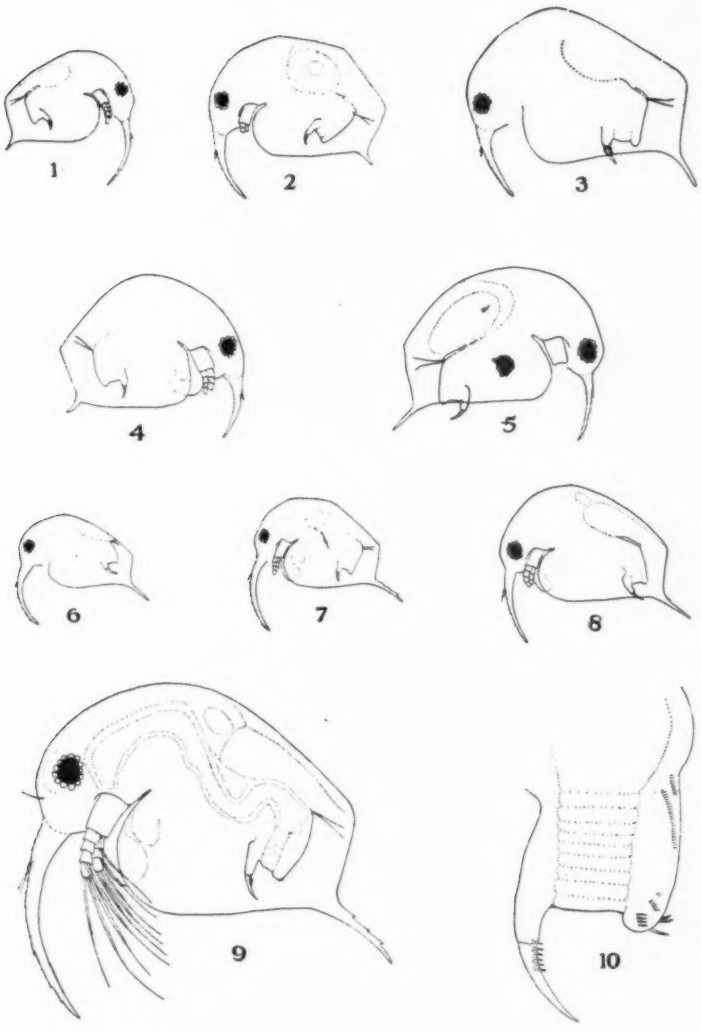
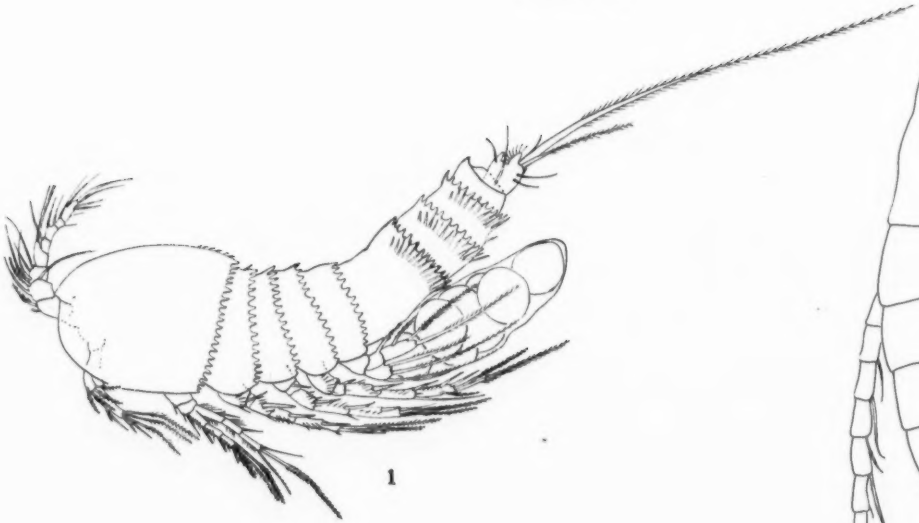


PLATE 38



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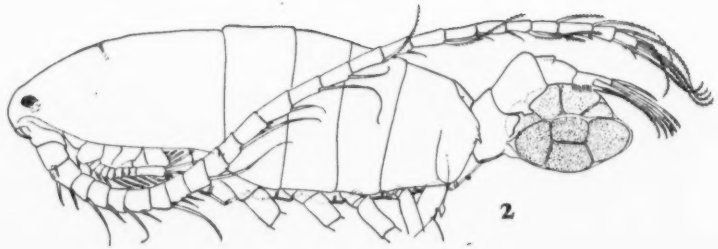

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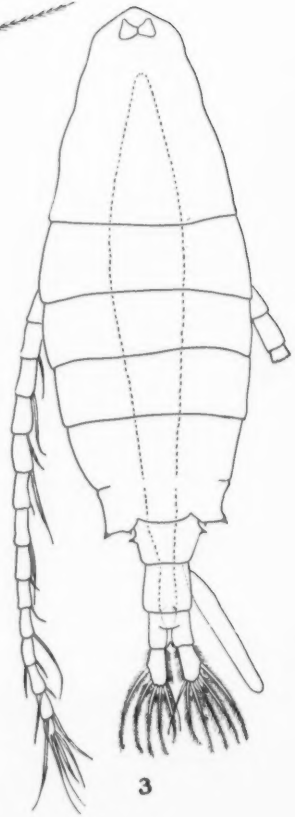

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PLATE 39

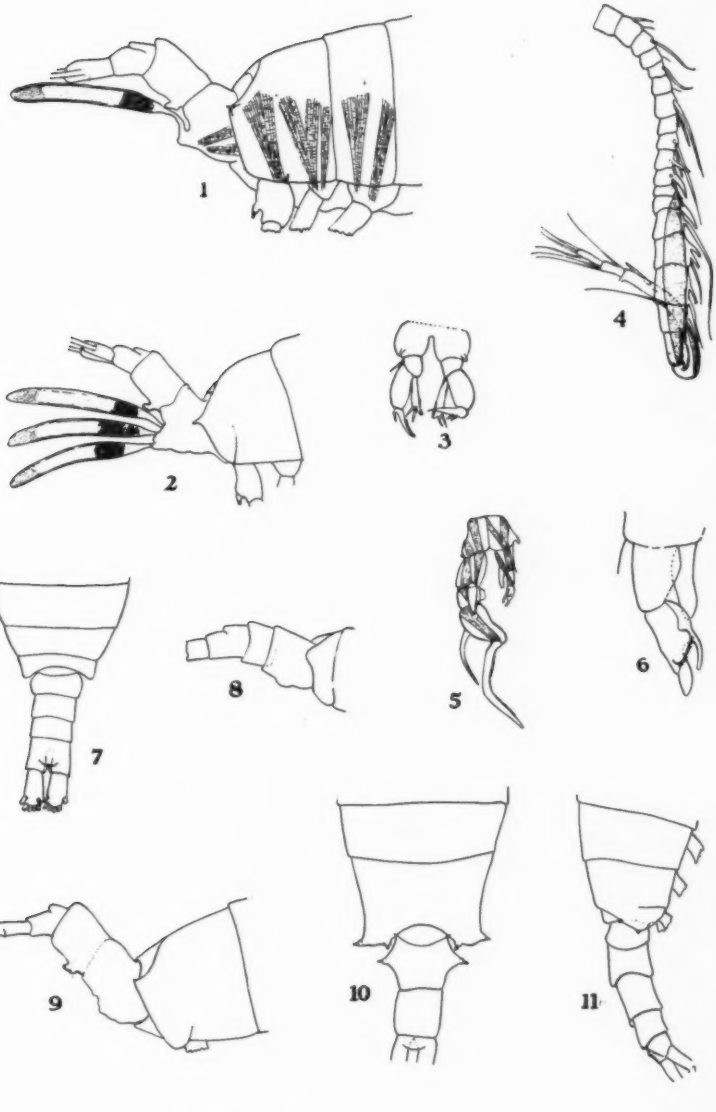
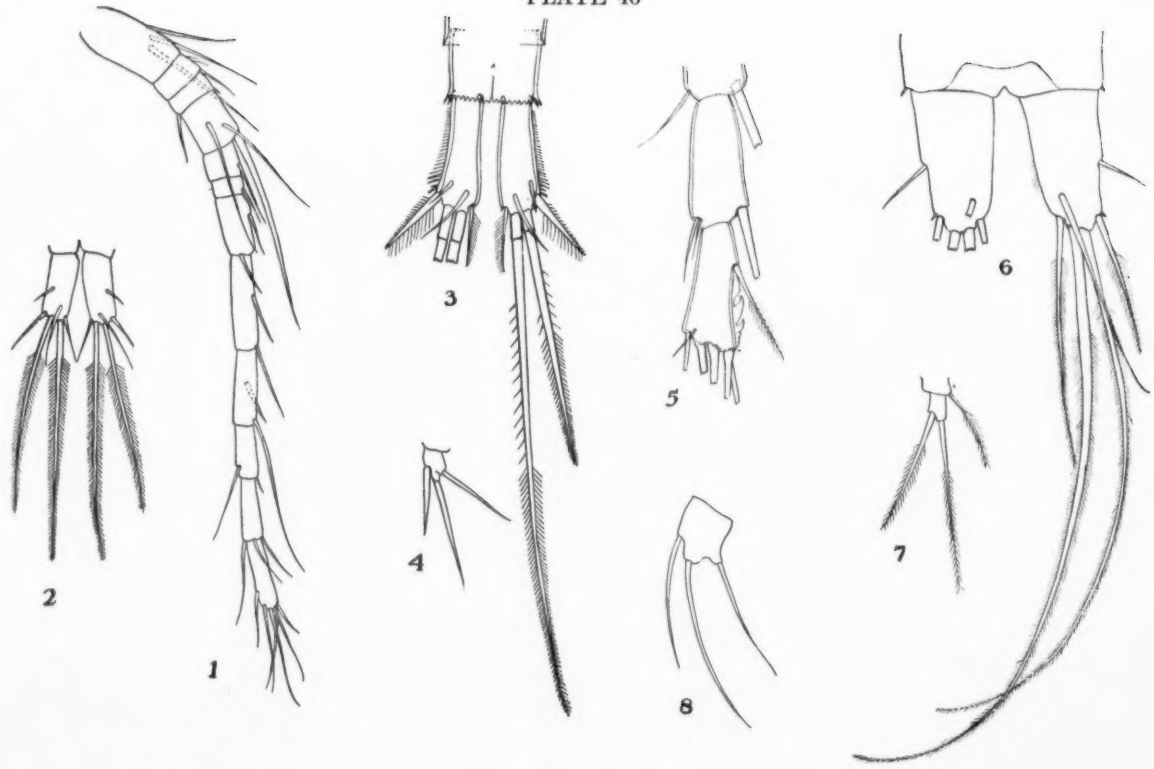


PLATE 40



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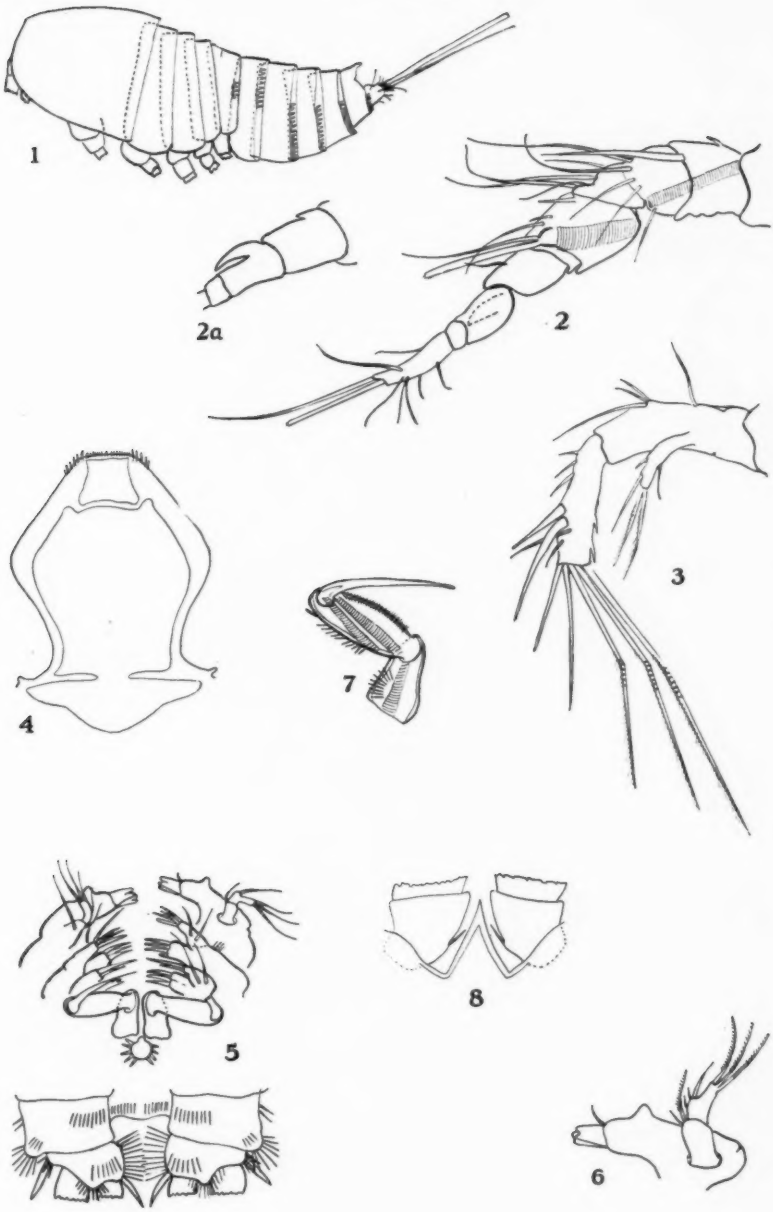

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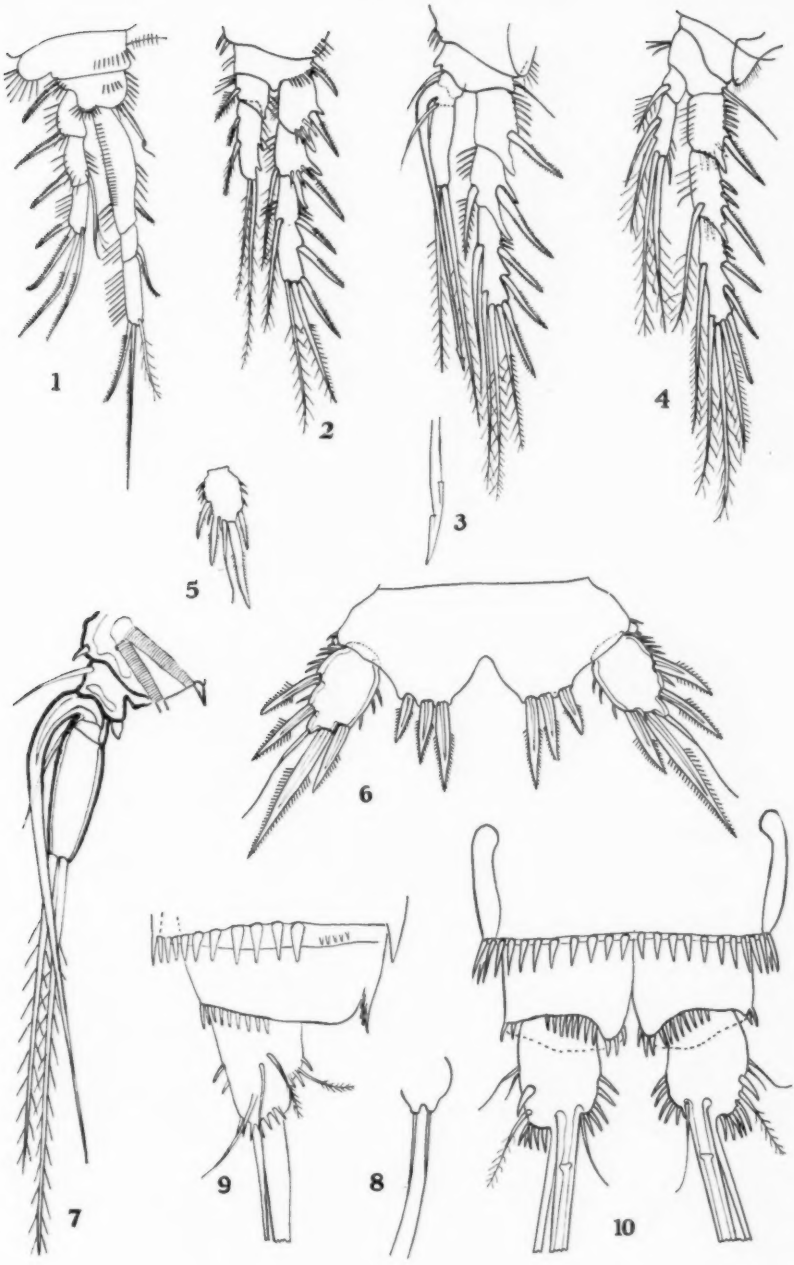

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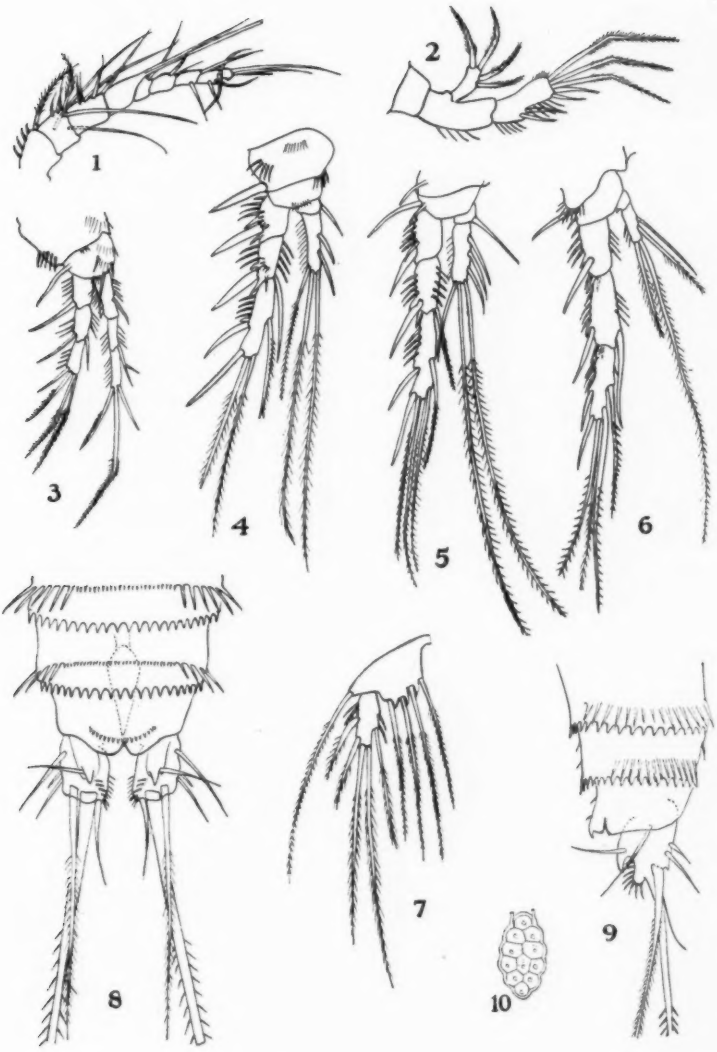

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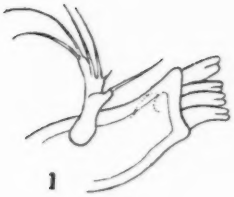

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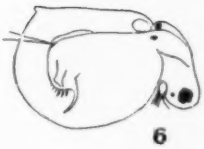

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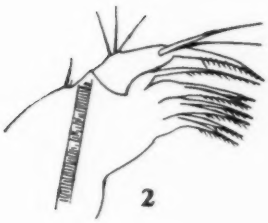

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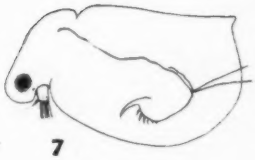

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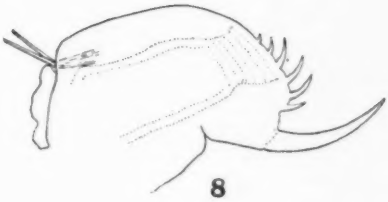

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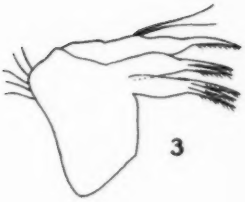

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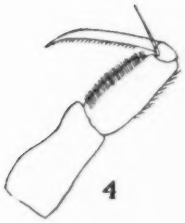

4

9

10

THE MODERN ELECTROMETER

Its Theory and Construction

By Otto Stuhlman, Jr.

Plates 45–50

On looking over the technical scientific literature of the day one is more and more impressed with the adoption by the "applied" sciences of those instruments which were once almost regarded as curiosities in the research laboratories of the so-called "pure" physicist. Amongst the most recent and astonishing of these adaptations is that of the quadrant electrometer.

Perhaps the earliest and best known type is that developed by Lord Kelvin. This was subsequently followed by the electrostatic voltmeter. The essential principle upon which they were designed was the attraction or repulsion that comes into play when you have a very light electrically charged disc or needle, acted on by an electrostatic field produced by the difference of potential which you wish to measure.

These and other earlier types were, however, more often used to illustrate interesting principles in physics than as instruments of precision. The more recent Dolezalek type of quadrant electrometer has however become in the hands of the physicist, the radiochemist and research engineer a common tool, used extensively where very small current measurements are made, which are impossible to measure with a galvanometer. It has, however, an additional particularly important use, namely, that of measuring accurately potential differences, and by connecting the needle of the electrometer to one pair of quadrants the instrument may be used for the measurement of rapidly alternating potentials.

This type is shown diagrammatically on plate 45. It consists essentially of a flat cylindrical brass box "Q" which is cut into four quadrants, supported by means of amber rods "A." The diagonally opposite quadrants are connected by wires. A light needle "N" made of aluminum foil or very thin silvered paper, hollow in the middle, of "dumb-bell shaped" outline is suspended by a very fine quartz fibre or thin phosphor-

bronze strip, so as to swing freely inside the quadrants. It hangs horizontally and symmetrically as shown diagrammatically in plan and section (pl. 45).

The needle is free to move in a horizontal plane and in its position of equilibrium it hangs along the line of separation of the two pairs of quadrants. It is charged to a potential of about one hundred volts, generally by joining it through its suspension to a constant source of potential, in the form of a battery of dry cells, the other terminal of the battery being connected to earth. A very high resistance is introduced between the needle and battery terminal to which it is connected, to prevent the possibility of a short circuit, should the needle accidentally touch the quadrants.

If on charging the needle, the zero position is displaced, it usually shows a lack of symmetry in its position with respect to the quadrants. The needle is then brought back to zero by adjusting the leveling screws "S" and then discharging. These operations are repeated several times until there is no appreciable change in the zero position on charging and discharging the needle, which then hangs symmetrically between the quadrants.

With the needle charged to a high potential, any difference of potential applied to the two sets of quadrants, will produce a deflection of the needle. This deflection is usually read by the movement of a beam of light reflected from the small mirror "M" attached to it. It can be shown that the deflection produced by the difference of potential on the quadrants is proportional to this difference of potential, providing the angle of deflection is small. Also providing that the difference of potential to be measured is small compared with the potential of the needle. This method, in which a constant and independent potential is given the needle, is known as the heterostatic method of using the instrument. When considerable differences of potential are to be measured the independent charging of the needle is unnecessary; the needle is then connected to one pair of quadrants and the quadrants connected to the source of potential to be measured. This is known as the idiostatic method of using the instrument. With this arrangement the electrometer may be regarded as an air condenser, one plate of which is movable.

The deflections thus obtained with potentials of the same magnitude but of opposite signs should be symmetrical with respect to the zero position. To test the uniformity of the scale-deflection, the instrument can be calibrated in the following way: A current is sent through the

resistance "A–B" (pl. 45, fig. B) from the battery, one terminal of which is earthed. The resistance A–B should be large, and a sub-divided megohm is suitable for the purpose. The insulated quadrants of the electrometer are connected to different points of the resistance so as to be brought to different potentials while the other quadrants remain earthed. A curve plotted showing the relation between the potential applied and the deflection of the electrometer needle should be linear. With an electrometer thus adjusted a deflection of the order of 1000 millimeters per volt can be obtained on a scale placed a meter from the electrometer. With exceptional care and a fine Wollaston Wire (Platinum) suspension 2500 divisions per volt have been obtained.

The electrometer can, however, also be used as a current measuring instrument. Under these conditions the rate at which the quadrants charge is given by the speed of the needle's deflection as observed on a ground glass scale placed at the usual meter distance.

The simplest way of carrying out these measurements, when the current is small is to observe with a stop watch the time required for the electrometer needle to be deflected through a definite angle. This method does not give reliable results unless the motion of the needle is slow and does not exceed about 20 millimeters per minute, on a scale placed about one meter from the electrometer. When the motion of the needle is more rapid, it is well to reduce the sensitiveness by inserting a condenser. This can be done by connecting to the insulated quadrants of the electrometer one terminal of the condenser, the other terminal of which is earthed. The current to be measured must now flow into the condenser as well as into the electrometer, with the result that the quadrants charge less rapidly.

The capacity of a Dolezalek electrometer and its connections is usually about 50 cm. When a large reduction in sensitiveness is required a sub-divided mica condenser of the ordinary type can be used with advantage. When small capacities are required it is preferable to work with air condensers possessing small insulating supports of sulphur or quartz, on account of the trouble due to residual charges absorbed by other types of insulators.

According to the theory usually given the angle of deflection $\Phi = C\ (v_1 - v_2)\ (V - \frac{v_1 + v_2}{2})$ making the sensibility proportional to $(V - \frac{v_1 + v_2}{2})$, where V is the potential of the needle and v_1 and v_2 are the potentials of the quadrants. Thus with v_1 and v_2 small, the

sensibility should be proportional to V. In point of fact, however, the sensibility generally reaches a well defined maximum as the potential of the needle is raised. In the lower half of figure 6 such a sensibility curve is given as could be taken from a Dolezalek electrometer with a very fine phosphor-bronze suspension. This is the usual type of sensibility curve obtained from this type of instrument. It should be noticed that at first the sensibility (division deflection per volt on the quadrants which are connected to the source which is to be measured) increases in proportion to the voltage on the needle. With further increase in needle potential the sensibility rises less rapidly to eventually pass through a maximum from where it falls off rapidly. It is customary to use the electrometer at maximum sensibility in order that small changes in the potential of the needle may be without sensible effect on the readings of the instrument.

Much has been written to explain this curious behavior, the chief contributions being those by Gorry (Journal de Phys., p. 97, 1888), Ayrton, Perry and Sumpner (Phil. Trans., A. 182, p. 519, 1891), Walker (Phil. Mag., p. 238, 1903), Orlich (Ziet. fur Inst. **23**: 97. 1903) and by R. Beatie (Electrician **65**: 729. 1910; **69**: 233. 1912). To reduce these mathematical papers to a semblance of simplicity and elementary physical elements is the object sought in the subsequent discussion.

The method followed by the above writers is to write down an expression for the energy of the system in terms of the potential and the position of the needle, and from this by differentiation to derive the value of the force acting on the needle. It is more direct, however, to follow the presentation given by Beattie and start with the forces and equate the controlling and deflecting couples acting on the needle. We must first however fix our attention on what is meant by the underlying physical principles by which an electrometer deflection is governed, namely the "controlling couple" and the "deflecting couple." By "controlling couple" we shall understand to mean the total couple on the needle for all causes, when it is charged to its working potential V. The quadrants being all connected to earth or zero potential. The "deflecting couple" is then produced by such additional electrical forces which affect the needle when the quadrants are raised from their zero potentials to some potential v_1 and v_2, the difference between which is to be measured.

The present theory, is developed on the assumption that the controlling couple on the needle is not due to the suspension alone but in reality arises partly from the suspension and partly from electrical

causes. This will be clearer on referring to plate 46, in which (a) represents diagrammatically an electrometer with its needle charged to a potential V and its quadrants earthed or at zero potential. In an electrometer of the symmetrical type where the needle is displaced from its symmetrical position by placing a potential V on the needle two forces come into play to bring the needle back to its original position. The twisted suspension contributes the mechanical couple proportional to the angle Φ and hence equal to $C_1\Phi$ where C_1 is a constant. In addition there is the electrostatic attraction between the needle and the quadrants which would of course pull the needle back to its original position were the suspension tortionless. This restoring couple here called the "electrostatic control" is proportional to the square of the potential on the needle V^2 and also to Φ and is therefore equal to $C_2V^2\Phi$ where C_2 is a constant. Hence the total controlling couple is then $(C_1 + C_2V^2)\Phi$.

It is possible for the above electrostatic control to act in the opposite direction to the mechanical control. Under these circumstances we have the conditions represented on plate 46, fig. b. If therefore we call the electrostatic control negative under these circumstances we have as a result the controlling couple equal to $(C_1 - C_2V^2)\Phi$.

Let us next charge the pairs of quadrants to a potential v_1 and v_2, respectively, and determine the effect on either control. Due to this rise in potential of the quadrants from the zero to their respective potentials v_1 and v_2, the needle now experiences a couple tending to deflect it in the direction as shown on plate 46, figs. c, d. Let us assume that v_1 and v_2 are small compared with V, which is usually the case in practice, then the deflecting couple will be proportional to $V(v_1 - v_2)$, but will vary in magnitude with the position of the needle with respect to the quadrants. If the resulting deflection is small however, and the same when the potential on the quadrants is reversed, then the deflection couple can be shown to be to a high degree of accuracy equal to $C_3V(v_1 - v_2)$ where C_3 is an arbitrary constant.

So that by setting the deflecting couples equal to the total controlling couples, for any case, we get in general

$$(C_1 \pm C_2 V^2)\,\Phi = C_3 V (v_1 - v_2)$$

and

$$\Phi = \frac{C_3 V}{C_1 \pm C_2 V^2}(v_1 - v_2)$$

or the sensibility

$$\frac{\Phi}{v_1 - v_2} = \frac{C_3 V}{C_1 \pm C_2 V^2}$$

Now this relation conforms to the variation in sensibility as is shown to exist by the lower curves in plate 48, and is a much more complicated phenomenon than the simple and older theory seems to imply. From the above we see that the sensibility reaches a maximum when $C_2V^2 = C_1$, that is to say, when the potential on the needle is such that the electrostatic control is equal to the mechanical control. Here the electrometer is most sensitive and therefore most useful, and this should be the conditions sought for in practice.

If, however, the electrostatic control were zero, we have an ideal situation represented by the dotted straight line, where, no matter to what potential the needle is charged the sensibility would always be proportional to that potential. If, however, as sometimes occurs the supposedly horizontal needle of the electrometer becomes slightly tilted relative to the quadrants, it may happen that the electrostatic and mechanical controls oppose each other and conditions arise as on plate 46, fig. b. Then any difference of potential applied to the quadrants will produce a deflecting couple as shown diagrammatically in the same figure at d. and by the upper set of curves on plate 48, termed "negative control." Here the sensibility of the electrometer becomes infinite for very large potentials on the needle, or also when the potential of the needle is such that the electrostatic control is equal to the mechanical control. If V exceeds this control value, the needle becomes unstable.

A. H. and K. T. Compton (Physical Review, Aug. 1919) took advantage of this characteristic, but did not leave it to chance construction or to accidental dissymmetry in the needle. They produced negative electrostatic control artificially through an intensional tilt of the needle and likewise through an intentional dissymmetry in the relative position of the quadrants. An additional valuable asset exists in that their electrical system has been made small enough to appreciably decrease the capacity of the electrometer. Further than this, they have shown that it is practical to construct an electrometer with an electrostatic control that is positive or negative depending on the position of the inclined needle in the non-symmetrically placed quadrants.

Beattie in his paper in 1912 in discussing the theory of the electrometer points out various conditions of electrostatic control as they might exist under very simple practical conditions. For instance with a needle completely boxed in as shown on plate 47 and free to move parallel to itself. The only electrostatic lines of force effective in producing a deflection of the needle are those which come from the "fringes"

at the edge of the needle, here indicated by N − N. If the needle is now displaced from its central position, the number of lines of force leaving the advancing edge must increase owing to the edge approaching the side N of the box. For a similar reason the number of lines of force leaving the retreating edge must decrease. On the whole the resultant force on the needle due to electrostatic causes is in the direction of the displacement, and the electrostatic control is negative. Again in plate 47, fig. b, with a needle between parallel plates which are separated by a very narrow gap G.G., the electrostatic forces on the needle tending to displace it parallel to itself are entirely the result of the fringes at the edge of the needle. If the gap G.G. between the plates is very narrow the fringes from the two edges will be similar in whatever position the needle may be placed and will therefore always excite equal and opposite pulls. In this case the electrostatic control is zero. But if the gap G.G. is made wide as that shown on plate 47 (c) we have "fringes" not only at F_L (left) and F_R (right) but also at F_L' and F_R'. If the needle is now displaced from this position toward the right the fringes at F_L are distorted in such a way as to exert a greater pull, at the same time the fringes F_R and F_R' are separated and as a result, the pull of the lines at F_R decreases. Thus the electrostatic forces brought into play oppose the displacement, or the electrostatic control is positive. This explanation as Beattie points out is of course only a rough one but it helps to make clear how the positive electrostatic control in the ordinary quadrant electrometer arises and how it depends on the width of the gap between the quadrants. Other things being equal the effect of the gap is obviously less the further they are removed horizontally from the side of the needle.

Such methods are not infallible, however, and often it may be impossible to predict the sign of the electrostatic control with certainty as for instance in plate 47 (d). Here if the edges N are far removed from the needle the electrostatic control arises from gaps G. G. solely and must therefore be positive. If on the other hand the edges N are close up to the needle the effect of the gap is relatively small and the control becomes negative as on plate 47 (a). This example helps to illustrate how readily positive control may be converted into negative control by a simple structural alteration in the electrical system.

This has been taken advantage of and structurally exaggerated in Compton's modification of the electrometer. The approximate electrostatic field with its unusually large negative electrostatic control is shown in the lower cut on plate 47. This in diagram represents the

conditions existing in this electrometer. Here the conditions are such that when the sensibility is determined for changes of potential on the needle, we get a series of curves, types of which are represented by those shown on the upper half of plate 48. To the right in the same figure are shown the various relative positions of the quadrants, as the instrument changes from negative to positive control.

On plate 50 is shown the control system of the electrometer with one quadrant pushed aside. This allows room for the removal of the needle. The front, back and removable quadrant are all in the same plane. The quadrant to the right can be shifted up or down by means of the slow motion screw entering from above. The complete instrument is shown to scale on plate 49. The quadrant system, made of brass, is very much smaller than that used in the Dolezalek instrument. It is 19 × 6 mm. overall, only one set of insulating leads pass through the central ambroid insulator. This results in a capacity of about 12 cm. The needle and plane mirror comprise one unit and the quartz fibre suspension another. The fibre is rather a coarse one, 3 cm. long and covered with a platinum deposit, so as to make it conducting. The needle is of aluminum leaf 12 mm. long and 6 mm. wide at its outer edge. Its major axis is very slightly tilted. The aluminum wire supporting the needle has attached to it a plane mirror 10 sq. mm. in area. With the movable quadrant slightly raised above the plane of the other three, this instrument has a working sensibility up to 50,000 mm. per volt at a scale distance of one meter. An easy working range is about 0-20,000 mm. per volt. Deflections are, however, only proportional to the voltage across the quadrants over a limited range.

The most serious sources of difficulty appear to be irregularities in the needle or quadrants and contact difference of potential between needle and quadrants. Of course contact difference of potential may be removed by permanently applying a compensating potential to the opposite set of quadrants. The writer has reduced contact difference of potential to zero by making the quadrants out of the same material as the needle and avoiding all solder in the operation of joining the various parts within electrical influence of the needle.

The period of the moving system increases with its sensibility and varies from approximately two seconds at very low sensitivity, to approximately ten seconds at 20,000 mm. per volt. It has, however, the very important property of being dead beat. Another remarkable advantage exists in that its great sensitivity (20,000 mm. per volt) may be obtained by the application of only 20 or 30 volts to the needle.

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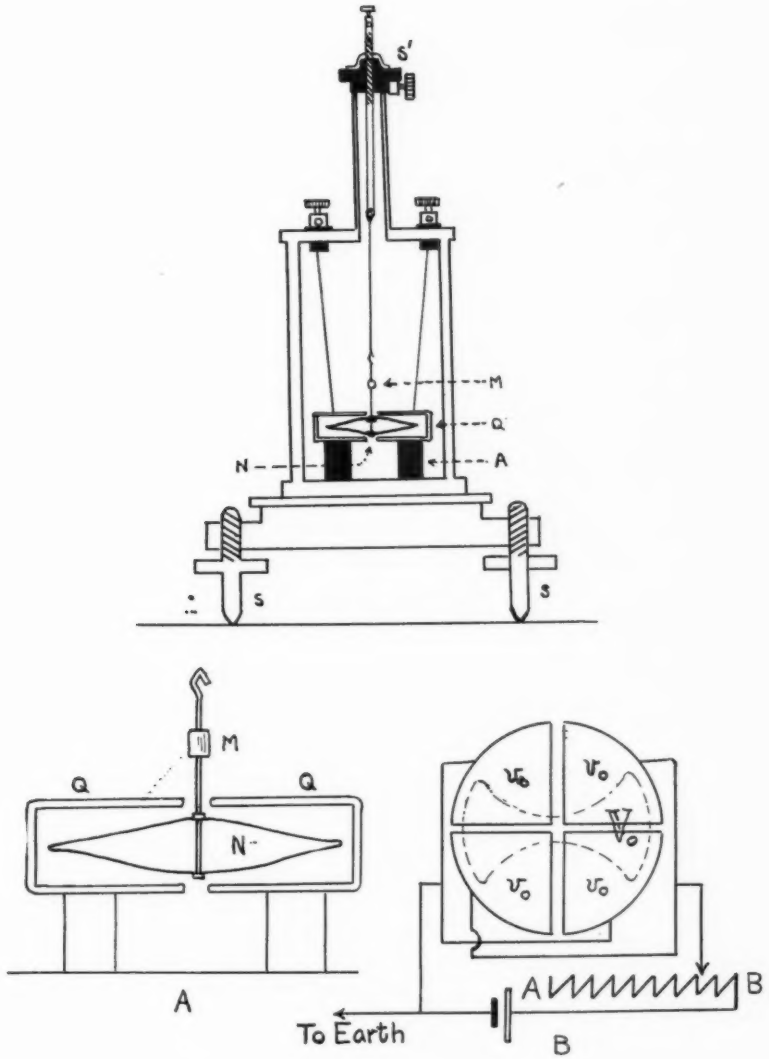
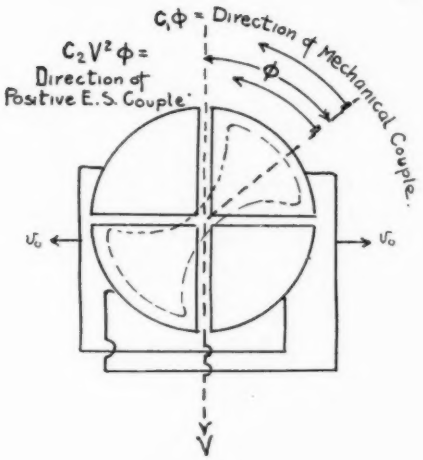
PLATE 45



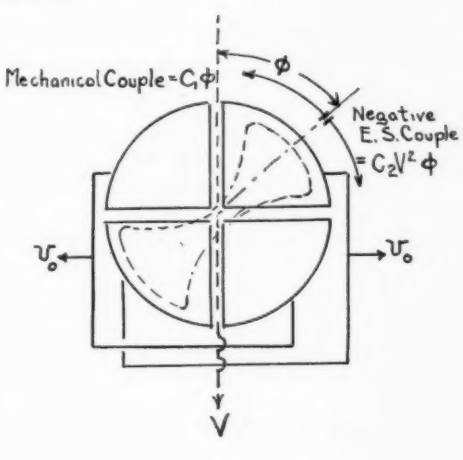
The Dolezalek electrometer in section and plan

PLATE 46



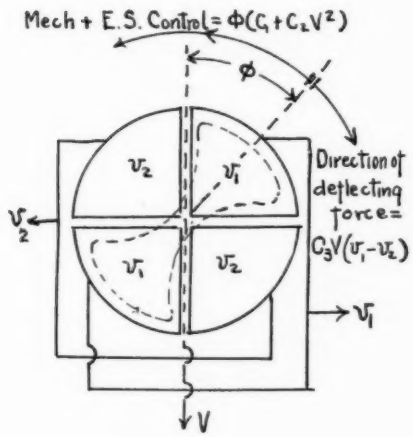
a.

Needle under positive electrostatic controlling forces.

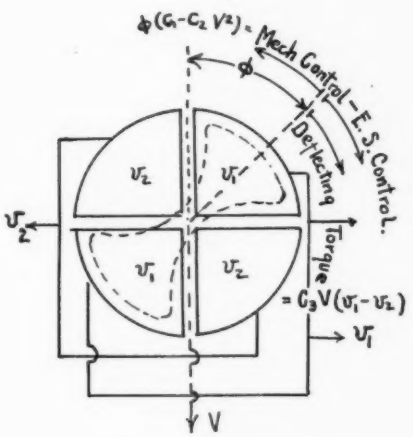


b.

Needle under negative electrostatic controlling forces.

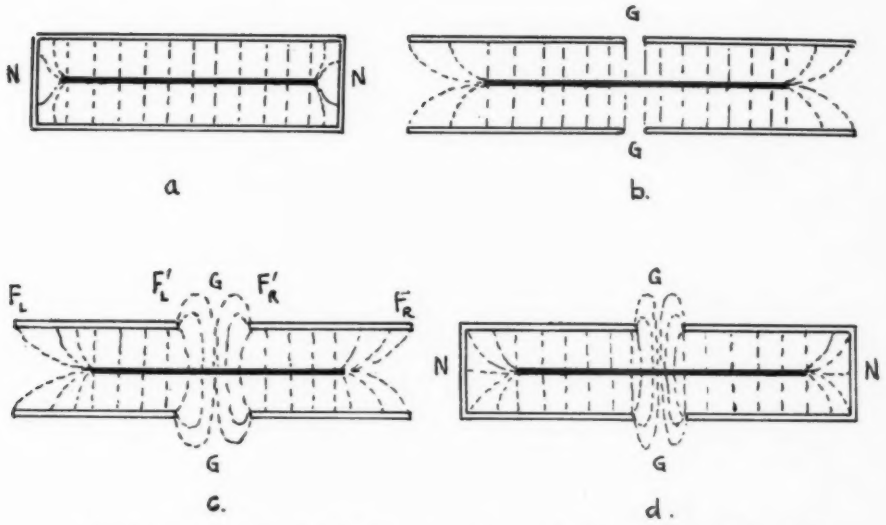


c.

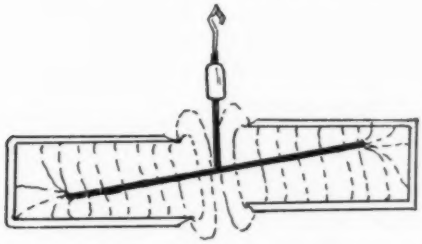


d.

Needle under controlling and deflecting forces.



Illustrating Method of Determining Sign of Electrostatic Control.



Approximate electrostatic field in Compton's modification of the Electrometer.

PLATE 48

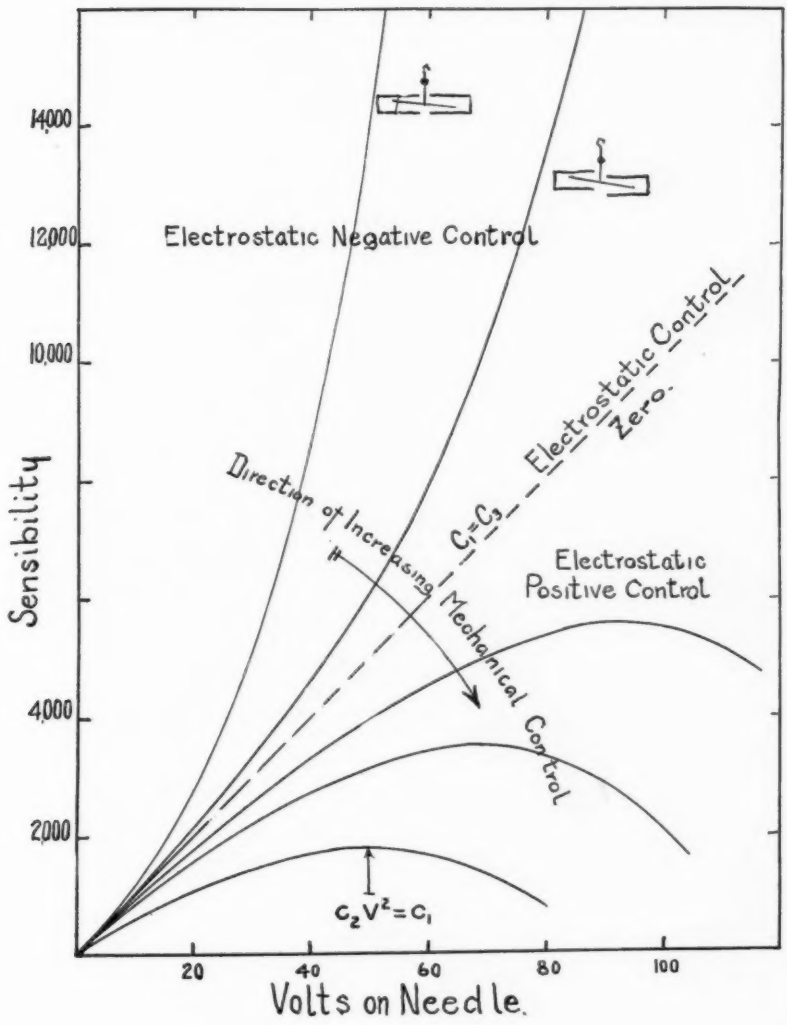
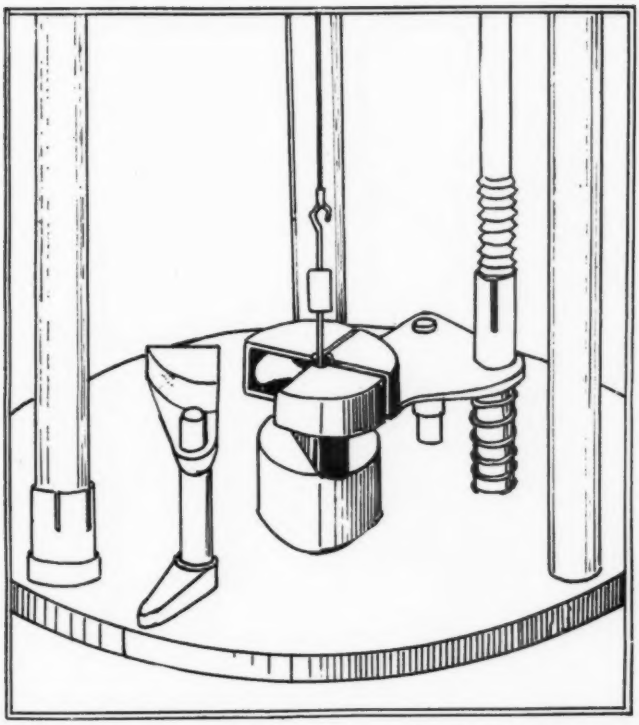

14,000
12,000
10,000
4,000
2,000
Sensibility
Electrostatic Negative Control
Direction of Increasing Mechanical Control
$C_1=C_2$ — Electrostatic Control Zero.
Electrostatic Positive Control
$C_2V^2=C_1$
20
40
60
80
100
Volts on Needle.

PLATE 49

Compton's modification of the quadrant electrometer

PLATE 50



Needle and quadrant system of Compton's modification of the electrometer with one quadrant pushed aside

NOTES ON WOODY PLANTS

By W. W. Ashe

Castanea alnifolia Nutt.—Nuttall in 1818 (Gen. **2**: 217) thus characterized this species in the original description: "Very low and shrubby, leaves elliptic-obovate, obtuse . . . . underside pubescent, middle nerve strigose, margin ciliate. In dry and sandy forests of South Carolina . . . . Leaves . . . . broadest towards the summit, serratures crowded, under surface minutely and uniformly pubescent but not tomentose." Fruit not described. In 1842 in his Sylva (**1**: 36), supplementing that of Michaux, *C. alnifolia* and its variety *pubescens* are thus described: "*C. alnifolia* . . . . foliis, subacutis, ... junioribus subtus pubescentibus . . . . β. *pubescens*-Foliis brevioribus, adultis subtus pubescentibus. I first met β in the vicinity of Charleston, S. C., afterwards the smooth kind much more abundant and in flower in March around Tallahassee in West Florida."

It is evident that the original description of *alnifolia* refers to a pubescent plant from South Carolina; and that the redescription in the Sylva is that of a plant from west Florida the young foliage of which only is pubescent; and that in the later publication *alnifolia* as originally characterized is made the variety *pubescens*. It now appears that the two plants, one with leaves acute and in part glabrous and the other with all leaves pubescent and largely obtuse, are quite different, though both are shrubby. From present information the pubescent plant extends from South Carolina near the coast to southeastern Louisiana and as far south as Gainesville, Fla. The form which has only the earlier leaves pubescent seems to extend from southeastern North Carolina to Newton County, Texas. The original description of *alnifolia* can be amplified as follows:

The twigs are very slender and either glabrous as they develop or glabrous or minutely pubescent by the time the leaves are mature, rarely remaining grayish pubescent throughout the season. The leaves on sterile branchlets are oblong-obovate, rounded at apex, broadest above the middle, gradually narrowed to the base, very dark green above, finely white pubescent below except on the usually glabrous midrib. The leaves on fruiting twigs are larger, lanceolate, often acute

at apex and at times nearly glabrous beneath. There are 2 to 4 flowers usually in pairs on the fertile aments. The fruit, usually a pair at the end of the glabrous or minutely pubescent 1 to 2 cm.-long peduncle, is 2.5 to 2.9 cm. thick, the involucral spines closely set, forked at their base and sparingly pubescent. The solitary nut is from 1.1 to 1.6 cm. thick.

Castanea paucispina sp. nov. A dwarf shrub with subterranean stems, branches 0.3 to 0.6 m. high, leaves oblanceolate or broader, obtuse or acute at apex, but not rounded, usually cuneate or much narrowed at base, 8 to 12 pairs of prominent veins; upper leaves on twigs usually closely white pubescent, lower mostly shorter and broader, green and glabrous below. Involucre scantily beset with branching, canescent spines. Type W. W. A., Newton County, Texas, October 19, 1921. *C. alnifolia* has leaves on sterile shoots, rounded at apex and of a decidedly oblong-obovate shape. In the proposed species these leaves are obovate, or broader and pointed.

Of the arborescent species *C. ashei* Sud. is most closely related to *C. alnifolia* and *C. paucispina*. The fruiting spike in *alnifolia* is short, 2 to 4 cm. long, seldom with as many as four burrs. In *C. ashei* the fruiting spike is often 8 cm. long, there are frequently as many as eight burrs, the peduncle and twigs are often closely gray pubescent, while the leaves are soft, velvety tomentose beneath, and as a rule, the spines on the burrs are thinly set, as in *C. floridana* (Sarg.) Ashe, and in *C. paucispina* proposed above.

Quercus venulosa hyb. nov. (*Q. caput-rivuli* × *Q. cinerea*). Leaves oblong obovate and acute, or obovate or oblong-obovate and rounded or obtuse at apex, often unsymmetrical and the margin often slightly wavy, awned at apex, 6 to 13 cm. long, firm, dark green, glabrous above with numerous impressed forking irregular lateral veins, buds narrowly ovate, acute, lower surface of leaves, twigs, and 1 to 2 cm.-long petioles more or less covered with short stellate pubescence. Fruit not seen. Both of the supposed parents common nearby. Turkey Creek, Okaloosa County, Fla. Type W. W. A. November 6, 1924.

Quercus Demarei hyb. nov. (*Q. nigra* by *Q. velutina*). Leaves 7 to 12 cm. long, prevailingly ovate in outline with 3 to 5 entire triangular abruptly acute lobes or sometimes oblong and with 2 or 3 rounded lobes, sinuses mostly broad and rounded at base, yellowish green especially the 2 cm.-long petioles, when mature nearly glabrous

below except for tufts of brown hairs in the axils of the vein. Twigs rather slender, nearly glabrous, in September, the ovate, blunt-pointed buds silky-tomentose at least above the middle. Nuts subglobose, pubescent, striped, about 1.5 cm. thick, the rather shallow cup somewhat pointed at base, the pubescent scales slightly squarrose or not tightly appressed. Both of the supposed parents are frequent nearby. The loosely pubescent bud scales and yellow petioles and midrib particularly point to *Q. velutina* as one parent. Near Conway, Faulkner County, Ark. Type Delzie Demaree and W. W. A., September, 1925.

Quercus borealis Michx. To the west of the Mississippi River this tree has been recorded from no further south than Iowa. In October, 1923, specimens were collected from Van Buren County, Ark., which were referred to this form and in September, 1925, it was collected at a number of places in Newton and Montgomery Counties in the same state. It will probably be found to be generally distributed in Arkansas throughout the Ozark Mountains.

Magnolia acuminata ozarkensis var. nov. This form differs from the typical eastern tree in its prevailingly slightly broader leaves which when mature are green and essentially glabrous on the lower surface. In the typical form the sun leaves are glaucescent and silky pubescent on the lower surface but the shade leaves even on the eastern tree are sometimes green and glabrous below; but when they have these characters their texture is very thin. The proposed variety is common on Pine Creek, Johnson County, Ark. (type W. W. A., May, 1924) and has been collected by B. F. Bush at Eagle Rock, Missouri. It seems to be the prevailing though not the exclusive form in northwestern Arkansas and extreme southwestern Missouri, having nearly the same distribution as *Castanea ozarkensis* Ashe.

Juniperus monosperma Sarg. In 1921 specimens of a *Juniperus* were collected near the White River in Benton County, and in September, 1923, the same form from Stone County, Arkansas. This material with 1-seeded fruit and large serrate leaves has been referred to the Rocky Mountain *J. monosperma*, heretofore not reported east of western Oklahoma.

WASHINGTON, D. C.

FURTHER NOTES ON HYDNUMS

By W. C. Coker

Plates 51–65

Since the publication of our earlier notes on *Hydnum* in this Journal (**34**: 163. 1919), we have found a number of other species in this state and have made careful studies and comparisons of these and others in the fresh condition. Such notes have been much needed to clear up certain obscurities in these plants. [See Beardslee's recent paper (Mycologia **16**: 255. 1924) as a good example of useful information.] We are taking this opportunity, therefore, to publish them, as well as certain observations on herbarium material, including all the fleshy Hydnums, a certain group of *Phellodon;* also a description of *Sistotrema confluens* and a few notes on *Steccherinum* and *Hydnellum*. We are adding for the North American continent *Hydnodon thelephorum*, a peculiar species of fleshy texture, hitherto known only from the tropics.

Hydnum fennicum and *H. amarescens* from Chapel Hill have been carefully compared with each other and with *H. Underwoodii* in the fresh condition. Including *H. imbricatum* we now have in Chapel Hill four clearly defined species in this group, and we are satisfied that we have them correctly named. We are using the name *amarescens* rather than *fulgineo-violaceum* for reasons given under that species. *Hydnum Underwoodii* is quite distinct from our other species and is as described from plentiful fresh material in our first publication. We have since studied it further and made careful comparisons as noted above.

Beardslee has shown that *H. laevigatum* as reported from America may well be old smooth specimens of *H. imbricatum*.

We can now add notes on *H. fuligineo-album* (sense of Boudier = *H. reticulatum* Banker) in the fresh condition. This seems to have been found but once before in the United States. We have found *H. cristatum* Bres. in Blowing Rock and made full notes, but unfortunately these as well as the plants were lost in a stolen package. We know of no illustration of the American plant and are publishing one herewith (pl. 52). This photograph is totally unlike Quélet's drawing of *H. acre* (Bull. Soc. Bot. Fr. **24**: pl. 6, fig. 1. 1877) which is supposed to be,

and perhaps is, the same. We are also adding a spore drawing of a North Carolina (Asheville) plant of *H. cristatum* sent to Bresadola by Beardslee. They are subspherical, warted, 3.7–4.8 x 4–5.5μ.

Of the fleshy species remaining *H. repandum*, *H. albo-magnum*, *H. imbricatum*, and *H. scabripes* are as described in our preceding paper, and are easily distinguished. *Hydnum albidum*, *H. delicatum*, *H. fumosum*, *Phellodon carnosus* and *Sarcodon Murrillii* are apparently good species, though some of them may have European names. We have examined the type specimens of *H. fumosum* and find them easily distinct, as well described by Banker. The spores we find to be somewhat smaller than he gives them (irregular, coarsely warted, 6.5–8.5μ, rarely 9μ). *Hydnum albidum*, *H. delicatum*, *Phellodon carnosus* and *Sarcodon Murrillii* are referred to below under their respective heads. For *Sarcodon roseolus* and *S. radicatus* see under *H. amarescens*. *Hydnum caespitosum* is referred to under *H. albidum*. *Hydnum Blackfordae* Peck and *H. atroviride* Morgan we know only from the descriptions. Dr. House writes us that he is unable to find the type of the former at Albany, and the type of the latter is probably destroyed.

We are adding a drawing of the spores of *Phellodon Ellisianus*, as a correction of the one shown in our former paper, which by some error was wrongly labelled. The spores are smaller and less warted than they were there represented. Plate 64 and part of plate 65 were drawn by Miss Alma Holland and both plates were inked in by her. Unless otherwise stated, collections are from Chapel Hill.

KEY TO THE SPECIES OF FLESHY STIPITATE HYDNUMS OF THE EASTERN UNITED STATES

Spores brown, warted (*Sarcodon*)
- Cap distinctly scaly at maturity, dark brown
  - Stem not pointed and not blackish green at base; teeth long (up to 1 cm. when fully mature)..... *H. imbricatum*
  - Stem blackish green at base
    - Teeth shorter (up to 5 mm.) flesh very bitter..... *H. fennicum*
    - Teeth very short (up to 1 mm., rarely 1.5 mm. when dry); plants usually infundibuliform..... *Sarcodon Murrillii*
- Cap hairy at maturity, color tan to ochraceous; spores 3.7–4.8 x 4–5.5μ *H. cristatum*
- Cap inherently scaly (no free scales except delicate ones in center), light brown to fawn; stem tapering to a fine point which is pure white at base; teeth up to 2 mm. long; flesh mildly bitter; spores 5.5–6.5 x 6.3–7.8μ..... *H. Underwoodii*

Cap smooth to pubescent or felted, not scaly
Young teeth violet.....*H. fuligineo-violaceum* (Sense of Beardslee)
Young teeth not violet
Plants large and heavy; base of stem not pointed and not blackish green
Cap pale flesh color; spores 6.5 x 7–8μ, with large thick warts *H. scabripes*
Cap dark brown; spores strongly warted, 5–7 x 6.2–7.5μ *H. imbricatum* (old smooth forms)
Plants medium to small; cap brown, usually with a distinct tint of vinaceous, felted to minutely squamulose; flesh vinaceous, very acrid and astringent; stem abruptly contracted below to a sharp point which is blue-black at base; teeth very short (up to 2 mm.); spores 3.7–5 x 4.8–6.2μ.....*H. amarescens*
Plants small; base of stem not pointed; cap gray to smoky brown when dry; spores subspherical, 6.5–9μ.....*H. fumosum*
Spores white, warted or echinulate; cap not scaly (anomalous)
Plants large, heavy; teeth 5–8 mm. long.....*H. fuligineo-album*
Plants smaller but firm and solid; teeth 1–2 mm. long.....*Phellodon carnosus*
Plants very small, soft and delicate; teeth up to 1.5 mm. long....*H. delicatum*
Spores white, smooth; cap not scaly (*Hydnum*)
Cap white; plant large and heavy; stem very short; spores 4.4 x 6–6.8μ *H. albo-magnum*
Cap buff to cream; plants usually of medium size, stem usually longer; spores subspherical, about 6.5–8μ.....*H. repandum*
Cap white to cream; plants medium to small, stem slender, tending to a cespitose habit; flesh turning orange (then brown ?) when cut; spores 5.5–7 x 7–9.5μ.....*H. albidum*
Spores pink, warted (*Hydnodon*)
Cap not scaly, soft and delicate, very thin.....*Hydnodon thelephorum*

Hydnum fennicum Karst.

Plates 51 and 64

Cap 3.7–11 cm. broad, smooth or nearly so in youth, soon becoming more or less scaly, about russet brown, at times with a tint of fawn or vinaceous; margin white and inturned in youth. Flesh thick, soft, pallid white, intensely bitter-farinaceous; odor slight, mildly farinaceous.

Teeth short (3–4, rarely 5 mm.), delicate, crowded, pallid in youth, then brown with pale tips.

Stem rather long, tapering downward and more or less pointed below (often much more blunt than is ever the case in *Underwoodii* or *amarescens*), color of cap except the base which is blackish olive or bluish green and often furnished with a superficial mold-like tomentum.

Spores (of No. 3414) strongly warted, subspherical, 5.5–6.5 x 6.8–7.5μ. Basidia 4-spored.

Well developed mature plants have the caps indistinguishable from forms of *H. imbricatum*, but the much shorter and more delicate teeth and blue-black base easily separate them. This is the plant now considered *H. fennicum* by Beardslee (Mycologia **16**: 257. 1924) and there seems no doubt that it is correctly named. In his first description of this species (Journ. E. M. Sci. Soc. **34**: 173. 1919) Beardslee treated it under the name of *fuligineo-violaceum*. We have examined a plant of *H. fennicum* from Karsten himself at the New York Botanical Garden and find it just the same as ours in the dry state. The present species differs from *amarescens* in squamulose-scaly cap, flesh not pink-violet, odor not of fenugreek, and larger spores.

Illustration: Karsten. Icon. Hymen. **2**: pl. 11, fig. 59 (as *Sarcodon*).

3414. Deciduous woods by Battle's Branch, Aug. 6, 1919.
3430. In woods just west of cemetery, Aug. 12, 1919. Spores dull chocolate brown, subspherical, 5.6–7.5μ.
3435. Deciduous woods west of cemetery, Aug. 16, 1919. Spores 5–6.5 x 5.5–7.2μ.
3447. Rich humus and leaves near Meeting of Waters, Aug. 16, 1919. Spores strongly warted, 5.2–6.5 x 6–7.2μ.
4628. In frondose woods near Meeting of Waters, Aug. 6, 1920. Spores exactly avellaneous (Ridgway), subspherical, about 5.5–7.4μ.
4641. Damp frondose woods near Meeting of Waters, Aug. 6, 1920.
4647. On high bank above Meeting of Waters, Aug. 7, 1920.

Asheville. Aug., 1918. Beardslee, coll. (U. N. C. Herb.). Spores strongly warted, subspherical, 5.2-7μ thick.
Linville Falls. On ground in rich deciduous woods, Aug. 24, 1922. (U. N. C. Herb., No. 5736.)
Blowing Rock. In thick deciduous woods, Aug. 17, 1922. (U. N. C. Herb., No. 5502.)

Sarcodon Murrillii Banker

Plate 64

This species is close to *H. fennicum*. It is known only from the type specimens in New York, and since these show certain differences from *H. fennicum* we are retaining the species at present. The dried plants have much shorter teeth than *H. fennicum*, 0.5–1 mm. long, and are distinctly more infundibuliform. All other characters can be matched in certain specimens of *H. fennicum*. The spores are the same (subspherical, 5–7μ).

Hydnum amarescens Quél.

Sarcodon roseolus Banker

Plates 53 and 64

Cap 3–7.7 cm. wide or compounded to somewhat larger, convex, the center flat or depressed and the thin margin sterile and incurved; surface felted-pubescent to minutely squamulose, the center soon subglabrous with low reticulated lines and points of agglutinated pubescence; color fleshy or vinaceous brown (varying from vinaceous buff through avellaneous to wood brown or fawn or Ridgway). Flesh soft, spongy, thick, flesh color with a tint of violet or deeper purplish vinaceous, acrid and astringent, constricting the throat; odor aromatic, about that of fenugreek with a slight fetid character, not unpleasant.

Teeth crowded, very short, about 1.5–2 mm. long with much shorter ones between, pointed, pale (dull whitish flesh) only when very young, soon color of cap, the tips concolorous or with whitish-tipped ones intermixed, then darker brown.

Stem about 3–4.5 cm. long, 6–11 mm. thick, bent, irregular, the base suddenly constricted to a small root, faintly felted and punctate with the decurrent teeth; color of cap except for the base which is lightly or deeply tinted with blue-green or even blackish olive both within and without though often superficially white from the mycelium; rarely hollow.

Spores (of No. 4373) between avellaneous and fawn (Ridgway), strongly warted, 3.7–5 x 4.8–6.2μ. Basidia 6.3–7.1μ thick, with 4 delicate sterigmata. Hyphae of cap flesh 4.8–7.4μ thick, no clamp connections present.

Easily recognized by small size, fleshy or vinaceous brown color all over, nearly smooth cap in both youth and age, pinkish violet flesh, greenish color of the inside of the stem base, very short teeth, peppery, astringent taste and fenugreek odor. All parts turn blackish brown when bruised, and this is especially noticeable on the cap margin.

This is in the immediate group with *H. Underwoodii* and *H. fennicum*. It differs from both in the smooth cap, purple flesh, different colored teeth and cap, and distinctive odor. Differs also from the first in the thicker teeth and bluish base and acrid taste; from the latter in shorter teeth, less deeply colored and more pointed stem-base. The teeth are reddish brown, not the paler brown of *H. Underwoodii* or the blackish brown with white tips of *fennicum*.

We are calling this *H. amarescens* because Quélet's good description of that agrees in all respects with our plants. *Hydnum fuligineoviolaceum* Kalchbrenner is very near, but the Florida plants so named

by Beardslee (Mycologia **16**: 258. 1924) have violet teeth in youth, and the base is not green. I have seen his dried plants and they look like ours. The spores too are the same, strongly warted, 3.7–4.5 x 4.4–5.2μ. In a letter Beardslee says: "My plants had no discoloration at the base of the stipe, and no decided violaceous color except in the teeth." The plant that Patouillard treats (Tab. Fungi **2**, No. 145) as *H. amarescens* is described as having violet teeth and the base is without green tint. This recalls Beardslee's plant but not Quélet's. I do not know which form is nearer the original *H. fuligineo-violaceum*. Kalchbrenner's figure shows neither violet teeth nor green base (Icon. Selectae Hymen. Hungariae, pl. 32, fig. 2), nor does Bresadola give these colors (Fungi Trid., pl. 139), his section showing the flesh brick red throughout the stem. We have a plant from Bresadola as *fuligineo-violaceum* that does not look just like ours. The base is less pointed and the teeth longer and less reddish. The spores are practically the same, 3.8–5 x 4.5–6μ (smaller than in *fennicum*). From the type collection at the New York Botanical Garden, *S. roseolus* Banker cannot be distinguished from our Nos. 3462, etc. The plants have the same color and the same pointed, deep olivaceous base. The spores are also identical (4–5 x 4.8–5.8μ). It seems probable also that *S. radicatus* Banker (Mycologia **5**: 13. 1913) is the same, especially as Earle noted a violet tint to the flesh. It was treated as *S. fuligineo-violaceus* in Banker's earlier paper.

Illustration: Quélet. Assoc. Fr. Avanc. Sci. **11**: pl. 11, fig. 14 (as *Sarcodon*). 1882.

3462. In rich humus and leaves near Meeting of Waters, Aug. 16, 1919. Spores strongly warted, subspherical, 4–5.6μ thick.

4373. Mixed woods by Battle's Branch, July 6, 1920.

4617. Mixed woods by Battle's Branch, July 31, 1920. Spores 3.7–5 x 4.8–5.8μ.

4640. Damp frondose woods near Meeting of Waters, Aug. 6, 1920. Spores 3.8–5 x 4–5.5μ.

4646. On bank above Meeting of Waters, Aug. 7, 1920.

Linville Falls. In rich woods, Aug. 24, 1922. Coker, coll. (U. N. C. Herb., No. 5733). Spores 3.7–5 x 4.5–6μ. Taste only mildly acrid.

South Carolina. Hartsville. Mixed woods by Black Creek, Aug. 31, 1922. Totten, coll. (U. N. C. Herb., No. 5842). Spores distinctly warted, 3.7–4.8 x 4.2–5.6μ.

Hydnum fuligineo-album Schmidt. Sense of Boudier.

H. fragile Fr. Sense of Banker
Sarcodon reticulatus Banker

Plates 54 and 64

Large and heavy; cap convex to nearly plane, uneven, usually depressed in center, much lobed and at times compound, the thin margin sterile for 1 or 2 mm. Surface not viscid, but holding much trash by attaching it with surface growth; color when not soaked pale dingy straw or dingy buff, sometimes with areas of pale chocolate in older plants; when soaked the color is watery cream with darker soaked-ochraceous spots and areas; surface composed of densely felted fibers which collapse to glabrous, except where they reach up around the trash or in much protected spots; not scaly. Flesh thick, about 8–18 mm. thick near center, white when young and fresh, more or less dingy later, and with the grub channels deep ochraceous, truly fleshy throughout, brittle and tender, a surface layer of about 1–3 mm. quite bibulous and immediately becoming water logged when wet, just as in *H. albomagnum;* taste mild, pleasant; odor almost none when quite fresh, soon mildly fetid-aromatic (fenugreek +), not so strong as in *P. putidus.*

Spines crowded, 5–8 mm. long, hardly decurrent, of medium stoutness, about 0.7 mm. thick at base, tapering evenly to a sharp point, nearly white then dusky gray with tints of light brown in areas.

Stem stout, short, 2–3 cm. long, 1.3–2 cm. thick or thicker when compound, equal except for spreading to the cap, base blunt, not at all pointed; surface color of cap; flesh solid, firmer and soon more dusky than that of cap but still light brown unless bruised, fibrous, brittle, no central core.

Spores pure white (in a good print), asperulate, 3–3.7 x 4–5μ. Basidia 5.5μ thick, 4-spored.

The plants are gregarious, at times fused, the stem central or subcentral, the odor suggesting fenugreek or melilot.

Our plants are in close agreement with Boudier's plate and description of *H. fuligineo-album* and also with a plant from Bresadola's Herbarium determined as such by him. Bresadola's plant cannot be distinguished from ours in the dry state and the peculiar odor is the same as well as the small characteristic spores (3–3.6 x 3.7–4.8μ). Bresadola's figures, on the other hand, are not like our plants and his description is also not in agreement. He considers Fries' figures (Icon., pl. 3) of *H. fuligineo-album* to be not that species but *H. laevigatum.* As understood by Bresadola *H. fragile* Fr. is not our plant, as shown by the specimens in his herbarium. The plants are more scaly with much longer, darker teeth, and larger and more strongly warted, dark spores. It looks like *H. imbricatum.* Banker, on the other hand, considers his *S. reticulatus*

the same as *H. fragile* Fr. (not Persoon). Banker's types of *S. reticulatus* are like our No. 3761, as shown by plants and spores (3–3.7 x 3.8–4.8μ). Both *H. fragile* Fr. and *H. fuligineo-album* are supposed by English and French authors to have white and warted spores and a strong odor. Perhaps they are the same thing. If the true *H. fuligineo-album* really turns rosy when cut (Boudier does not say this), the American plant might retain its special name, though scarcely more than a form.

In size, surface and texture of flesh our plants are very like *H. albomagnum*, from which they are separated by different color, warted spores, more aromatic odor and very different color when dry, the present species changing color very little, the other becoming yellow or orange. It is easily different from all other American Hydnums with soft flesh.

Illustrations: Boudier. Icon. Myc. 1: pl. 168.

3761. On ground under pine in a damp meadow, Nov. 16, 1919.

Phellodon carnosus Banker

Plate 64

This species is evidently related to *Hydnum fuligineo-album*, the two, together with *H. delicatum*, making up a peculiar group which does not fit properly into any of the established genera as interpreted by recent writers. The warted spores separate them from *Hydnum*, the white spores from *Sarcodon*, and the soft, fleshy, homogeneous texture from *Phellodon*. We have examined the specimens of *P. carnosus* from Vermont (Miss Burlingham, coll.) mentioned in the original description, and find the spores to be oval, minutely but distinctly warted, 3.6–4 x 4–5.5μ.

A European plant (Mendola) identical with this has been determined by Bresadola as *H. violascens* Alb. and Schw., as shown by a specimen from him in the New York Botanical Garden. The spores are 3.5–3.8 x 3.7–5.2μ.

Hydnum delicatum Schw.

Phellodon delicatus (Schw.) Banker

As represented by the Ellis collection from New Jersey now at the New York Botanical Garden (referred to by Banker), this seems to be a very distinct little species. The plants are delicate throughout, with a very slender little sub-central stalk. The teeth are short, stout and well formed. It is not at all like *Hydnodon thelephorum*, and it is also obviously different from *H. pusillum* Broter as the latter is represented

in the Bresadola Herbarium. *Hydnum candicans* Fries is nearer and should be carefully compared.

Hydnum albidum Peck

H. caespitosum Banning in Peck

Plates 55 and 64

Cap up to 3.5 cm. broad, irregular, convex or center depressed, often cracked, felted-tomentose or smooth, white or cream colored (sometimes flesh colored in the *caespitosum* form). Flesh up to 5 mm. thick, soft, mild, white.

Teeth white (or pale flesh color), up to 6 mm. long, very pointed.

Stem 3–7.5 cm. long, 4–6 mm. thick, enlarged below or above or both, uneven and crooked, white or creamy, solid, tending to a caespitose or crowded habit.

Spores (of No. 5603) pure white in print when fresh, turning creamy in the herbarium, smooth, oval, 5.5–7 x 7–9.5μ.

All parts of cap, stem and flesh turn slowly orange when rubbed or cut.

The pale caps, slender form and change of color indicate the above species. The spores as given by Peck and Banker are much smaller than in our plants, but we find the spores of the type collection to be just like those of our No. 5603. Dr. House has generously furnished us with two of the type plants, one of the larger and one of the smaller size, and both have large spores (about 4.8–7 x 7–8.2μ, most about 6 x 7.5μ). These plants in the dried state match some of ours exactly.

The situation is complicated by the presence in this country of a smaller and more delicate white plant with small spores, as given by Peck and Banker. Most of the plants referred to under *H. albidum* by Banker (l. c., p. 107) are of this type. For example the Peck and Earle No. 817 (Port Jefferson, Long Island) has spores 3.5–4 x 4–5μ. If two species are involved the one represented by these small plants must be given a new name. It is possible that the spores are exceptionably variable in this species. It is known that *H. repandum* itself varies greatly in size and delicacy, and there has been some doubt that *H. caespitosum* is really distinct from it. However, as noted above, the pale caps, slender form and change of color make it desirable to retain *H. albidum* for the present as a good species, with *H. caespitosum* as a form. Earle's Connecticut plants noted by Banker under *H. caespitosum* have exactly the appearance of ours except that they form a densely

cespitose group. Earle says "cap dark flesh color; spines light flesh; stem nearly white, stained with yellow."

A plant that looks exactly like our No. 5603 was distributed as *H. rufescens* Pers. (see specimen in the New York Botanical Garden) by G. von Beck, who considered it different from *H. repandum*. Peck considers *rufescens* a more reddish form of the latter (Rept. N. Y. St. Mus. **48**: 304. 1894).

Illustrations: Peck. Rept. N. Y. St. Mus. **51**: pl. 56, figs. 1–7. 1898.

North Carolina. Blowing Rock. In rich soil in mixed woods, Aug. 20, 1922. Coker, coll. (U. N. C. Herb., No. 5603).

Hydnodon thelephorum (Lév.) Banker.

Plates 56 and 64

Cespitose in partly fused groups or single, the whole making a sparse colony. Cap flabelliform, very irregularly expanded and usually lobed and divided, at times in a complicated way, 0.8–5 cm. broad. Surface uneven, dull white, becoming slightly discolored to yellowish or brownish, at times obscurely zonate, appressed fibrous to floccose or becoming glabrous; often translucent in places on drying as if semigelatinous. Flesh soft, very thin, drying almost to a membrane, tender and delicate; taste mild, pleasant; nearly odorless when fresh but with the odor of old ham when dry.

Teeth sometimes distinctly hydnoid but usually more or less amorphous, short (less than 1 mm.), terete or flattened into ridges, salmon or flesh color, as is also the hymenium between. The whole hymenium including the teeth is of a soft, subwaxy nature and easily removable from the flesh.

Stem lateral or eccentric, irregular, rather slender, about 1–2 cm. long, merging into the cap, covered in large part by the decurrent hymenium; base white.

Spores *pink* (noted by Earle for the Jamaica plant), pale ochraceous under microscope, both angled and warted, 3.4–4 x 4–5.5μ (in No. 7472) Basidia (of the Bahama plant) clavate, 5.5–6.3μ thick, 4-spored.

This is the first record of this from the North American continent. It was described from South America (Cayenne, French Guiana, and Chile) and has later been found in Jamaica and the Bahamas. Its discovery here is a remarkable extension from its tropical range. Banker (Mycologia **5**: 297. 1913) has correctly transferred the species to a new genus as it is in several respects remarkable. In habit and texture and in the more or less amorphous hymenium it resembles *Sistotrema confluens* (see below), but differs from that in

the rough spores, more complicated form, presence at times of truly spine-like teeth and in color both when fresh and dry. In drying the plants shrink greatly, the flesh becoming hard and brittle and the teeth appear usually as scarcely more than irregular tubercles. The colors beco me dull ochraceous, the hymenial surface with a more or less obvious flesh tint. Our plants are exactly like those from Jamaica and Bahamas cited by Banker, and Miss Wakefield has very kindly compared ours with authentic specimens from Léveillé in the Kew Herbarium. According to her measurements, the spores of these last are slightly smaller than in ours (3 x 3.5–4(–5)μ). Miss Wakefield writes that *H. lateritium* Massee, considered the same by Banker, is quite different, and that its spores (type) are smooth.

7472. In humus at the foot of a tulip tree, Aug. 5, 1924.

Bahamas. Crooked Island. In leaf mold on Stopper Hill. Brace, No. 4833. Jan., 1906. (N. Y. B. G. Herb. and U. N. C. Herb.) Spores angled and warted, 3.5–4 x 4–5.3μ.

Jamaica. Rose Hill. Elev. 3000 ft. Earle, No. 54. Oct. 24, 1902. (N. Y. B. G. Herb. and U. N. C. Herb.) Spores slightly colored under the microscope, warted, 3.8–4.2 x 4–5.3μ.

Morce's Gap. Murrill, No. 691. (N. Y. B. G. Herb. and U. N. C. Herb.) Spores minutely warted, 3.5–4 x 4–5μ.

KEY TO THE PHELLODONS OF THE EASTERN UNITED STATES[1]

(Odor in all the following at least when drying strong of fenugreek or more fetid)

Plants very small and thin, not over 1.5 cm. broad; blackish when dry except for the brown hymenium ..... *P. Ellisianus*

Plants larger

Entire plant when dry tough and semi-pliable

Flesh duplex, soft and spongy above, dense and firm below

Cap thin; stem slender and without a superficial spongy layer or bulb; dried teeth gray or brownish drab; spores 3.5–4μ; odor strong even when fresh ..... *P. graveolens*

Cap thin or thickish, flesh distinctly duplex, the lower layer and center of stem black and hard; base of stem with spongy thickening; dried teeth gray or brownish drab; spores about 3.4–4.2 x 3.7–5μ; odor when fresh none or faint, distinct on drying ..... *P. alboniger*

Cap thin or thickish, flesh duplex but lower layer and center of stem not black though hard; base of stem spongy-thickened; spores 3–3.8μ ..... *P. vellereus*

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[1] For *H. delicatum* (treated as *Phellodon* by Banker) and *Phellodon carnosus*, species with fleshy, homogeneous texture, see *Hydnum* key on p. 271.

Cap thicker, often large and stout; flesh as in *vellereus;* base strongly thickened; dried teeth yellowish or tawny brown; spores 3.5–4.3 x 3.8–5μ.....*P. putidus*
Flesh homogeneous, thin and fibrous.....*P. tomentosus*
Entire plant hard and brittle when dry, the softer surface layer very thin and not distinctly spongy.....*P. Cokeri*

Phellodon graveolens (Delast.) Banker

Plates 57 and 65

Cap 1–7.5 cm. broad, often compound by fusion, when well developed expanded, thin and depressed in center, surface with radial lines or ridges and faintly zoned or wavy; soft-felted so as to take the imprint of a finger, whitish (pale straw or creamy white) staining brownish when bruised. Flesh thin (2–3 mm.), fibrous, tough, subfleshy, about color of cap, a surface layer soft and spongy, brown then blackish if cut when fresh; taste mild, slight; odor fetid-aromatic, like *P. amicus,* distinct even when quite fresh. Dried plants except where bruised are smoky brown (cinereous).

Teeth close, very small and delicate, up to 1 mm. long, whitish then gray with a faint salmon tint, then brownish drab as in *alboniger.*

Stem small, about 1–2 cm. long and 3–5 mm. thick, no surface layer, tough, not black within when fresh or dry but turning brown or blackish throughout when bruised.

Spores (of No. 4375) pure white, papillate warted, hyaline, subspherical, 3.5–4μ.

As noted by Banker, there has been much confusion among the odorous species of *Hydnum.* We consider our plant the true *H. graveolens* because it agrees well with the first description by Persoon and with the figures of Fries. It is distinguished by delicate form, slender stem without superficial enlargement by spongy tissue, very short teeth, small, very delicately warted spores and very noticeable fetid-aromatic odor both when fresh and dry, approaching that of melilot or fenugreek, curry powder, etc. *Hydnum melilotinum* Quélet is almost certainly the same and so also may be *H. cinereum* Fries, though Fries does not refer to an odor. *Hydnum putidum* Atk. easily differs in heavy body and thick stem, thick flesh which does not turn black when bruised, longer spines, etc. *Phellodon alboniger,* which has a similar odor on drying, is easily distinguished by the duplex flesh with hard black interior, swollen stem with spongy sheath. *Hydnellum suaveolens* is easily distinguished by its hard core and flesh striped with blue and the blue mycelium.

Our plants agree completely with one distributed by Saccardo as

H. cinereum Bull. in his Mycotheca Venata, No. 825 (Path. and Myc. Colls., Washington). Spores subspherical, faintly rough, 3.4–4μ. There is considerable confusion about *cinereum* and *nigrum*. Batsch does not mention odor for his plant on which *H. nigrum* Fries was based, and Fries denies odor for this species. On the other hand Quélet in describing his species *melilotinum* refers to Batsch's figures as the same and gives the odor as of melilot. In establishing his *H. cinereum* Bulliard also refers to the same figures in Batsch. Fries retains the name *H. cinereum* for Bulliard's figures and refers Batsch's to his *H. nigrum*. Banker considers the following as synonyms of *P. graveolens: H. pullum* Schaeff., *H. zonatum* Gmelin (not Batsch), *H. melaleueum* Fries, *H. leptopus* Pers. (Mycologia **5**: 62. 1913). We have a plant from the Bresadola Herbarium as *H. melaleucum* Fries which is the same as our plants (spores 3–3.6μ, minutely warted).

Illustrations: Fries. Icones Selectae, pl. 6, fig. 1.

4375. In Tenney's Ravine, damp, sandy soil, July 6, 1920.

4625. Old Chapel Hill collection. No other data. Spores white, spherical, minutely warted, 3–3.8μ.

South Carolina. Hartsville. On bare bank by Black Creek, Aug. 31, 1922. Coker, coll. (U. N. C. Herb., No. 5861). Spores spherical, minutely warted, 3–3.8μ.

Connecticut. Redding. Sept. 6, 1919. Coker, coll. (U. N. C. Herb.). Spores 3–3.7μ thick.

Phellodon alboniger (Peck) Banker

Plate 65

Cap 2.4–5 cm. broad, convex then plane, rather even, the margin irregular, surface finely velvety-tomentose, pale cream or creamy gray, turning brown when touched except on margin which turns black when rubbed. Flesh duplex, the upper layer soft and about the color of the surface, the lower hard and black. In old age the surface layer collapses and becomes darker gray-brown and may disappear in places to show the black layer beneath. In this condition only the black layer and the more spongy base and slightly larger spores will distinguish it from *graveolens*. Taste slight, a little bitterish and fungoid, odor very slight or none when fresh, but becoming fetid when drying.

Teeth slender, crowded, 2–4 mm. long, pale gray, then gray-brown with a slight salmon tint; brownish drab when dry.

Stem about 2–4 cm. long, 4–15 mm. thick above, swollen below by a thick soft outer layer that is the color of the cap; inside black and hard.

Spores (of No. 3411) subspherical, minutely but distinctly spiny-warted, 3.5–4 x 3.7–4.8μ.

The species is much like *P. putidus* in shape, surface, color, etc., but is easily distinguished by the black inner flesh and slight odor when fresh. In drying the odor while fetid is not so rank as in *P. putidus*. *Phellodon niger* of Europe is not supposed to have an odor; otherwise it is very near *alboniger* (see under *graveolens*).

3411. In humus, frondose woods, Aug. 7, 1919.

3427. Mixed woods by Battle Branch, Aug. 11, 1919. Like No. 3411 but two young plants show a decided though pale tint of bluish lavender on under side of cap margin and young spines.

Blowing Rock. In leaf mold, Aug. 20, 1922. Couch, coll. (U. N. C. Herb., No. 5607). Spores pure white, spherical, spiny-warted, 4–5.2μ, with a distinct mucro.

Linville Falls. Deep deciduous woods, Aug. 24, 1922. Coker, coll. (U. N. C. Herb., No. 5727). Spores subspherical, 3.8–5μ.

Pennsylvania. Buck Hill Falls. Mrs. Delafield, coll. (U. N. C. Herb.).

New York. Horicon. July, 1905. Peck, coll. (U. N. C. Herb. and N. Y. St. Mus.).

Tripoli. Burnham, coll. (U. N. C. Herb.). Spores spiny-warted, 3.5–4 x 3.8–4.3μ.

West Fort Ann. Sept. 1917. Burnham, coll. (U. N. C. Herb.). Spores 3.5–4.2 x 3.7–4.5μ.

Connecticut. Redding. Two collections by Coker (U. N. C. Herb.). Spores 3.4–4.2 x 3.7–4.5μ (some smaller ones mixed).

Phellodon vellereus (Peck) Banker

Plate 65

We have not found this in the fresh condition but dried plants from various places show a close similarity to *P. putidus* except for more delicate structure. The spores, as shown below, seem to be slightly smaller in this form.

New York. Bolton. Peck, coll. (N. Y. St. Mus. and U. N. C. Herb.). Spores hyaline, subspherical, faintly spiny-warted, 3–3.6μ.

Sand Lake. Peck, coll. (N. Y. St. Mus. and U. N. C. Herb.).

Wading River. Two collections by Peck (N. Y. St. Mus. and U. N. C. Herb.). Spores 2.8–3.6μ.

Connecticut. Miss White, coll. (N. Y. B. G. Herb. and U. N. C. Herb.). Spores faintly spiny-warted, 3–3.7μ.

Maine. In moss in woods. Miss White, coll. (N. Y. B. G. Herb. and U. N. C. Herb.).

Phellodon putidus (Atk.) Banker

Plate 65

In our original paper this was considered the same as *P. amicus*. As Quelet describes the flesh as having purplish livid streaks and the spines as lilac gray, we think it best to keep these separate for the present. We have never noticed these colors in *putidus*, which is common in Chapel Hill. The species seems nearer *P. vellereus*, the colors and flesh of cap and stem being about the same. The spines when dry are more yellowish or tawny than gray, thus agreeing with *vellereus* and differing from *graveolens* and *alboniger*. About the only difference appears in the stouter and thicker structure of *putidus* and somewhat larger spores. It would seem to be scarcely more than a stouter and perhaps regional form of *vellereus*.

1368. In deciduous woods, Oct. 14, 1914. Spores subspherical, spiny-warted, 3.6–4.2 x 4–4.8μ.
2378. Mixed woods, July 8, 1916. Spores spiny-warted, 3.5–4.3 x 3.8–5μ.
3409. By Battle Branch, Aug. 7, 1919. Spores subspherical, 3.4–4.8μ.

Hydnellum sanguinarium Banker

Plates 58–60

Field notes on fine fresh plants of this species have convinced me of its identity with *H. velutinum* Fr. Our Nos. 3451 and 3452 yielded when pressed a distinctly reddish juice and in this respect only differed from No. 3426 which yielded no such juice. The latter was typical *H. velutinum* as described in our *Hydnum* paper, p. 183. Both those with and without the reddish juice are almost tasteless and with only a mild odor of woods earth. In the perfectly fresh condition the surface tomentum is covered with a grayish bloom which is of course most obvious on the margin.

The species is characterized by rusty brown color, softly felted cap with paler margin which turns blackish when bruised, duplex flesh, spongy stem base, and absence of decided odor or taste. The largest single plant we have found was 12 cm. broad.

Hydnellum velutinum is the name that should now be used as *H. ferrugineum* Fries is antedated by Persoon's name for a different plant. *Hydnum spongiosipes* Peck is also the same.

We list below only the collections illustrated, one with and one without the reddish juice. The plant is not at all rare in Chapel Hill.

3426. In low deciduous woods west of cemetery, Aug. 9, 1919.
3452. In sandy woods earth, deciduous woods north of Meeting of Waters, Aug. 16, 1919. Juice reddish.

Steccherinum pulcherrinum (B. & C.) Banker

Creolophus pulcherrimum (B. & C.) Banker

Plates 61 and 62

Since our first published notes on Hydnums, observations on the fine fresh plants illustrated herewith show that the soft flesh in the fresh condition contains a milk-white sticky sap which can easily be squeezed out. It is this dried sap which gives the plant its gummy feel when dry. We have not seen any other mention of this milk which is a highly distinctive character.

The soft, pliable, toughish flesh is composed of loosely packed coarse fibers.

Spores (of No. 3456) hyaline, oblong-elliptic, 2.3 x 4.5μ.

Illustrations: Coker. Journ. E. M. Sci. Soc. **34**: pl. 11. 1919.
Hard. Mushrooms, p. 446, fig. 375.

3456. On fallen oak, August 16, 1919.
4354. On fallen oak by Battle's Branch, July 1, 1920.

Sistotrema confluens Pers.

Plates 63 and 65

Plants 1–2 cm. high and 1–2 cm. broad, shaped like half a morning glory, i.e., fan-shaped with the margin reflexed, about as in single lobes of a large compound *Polyporus* like *P. frondosus;* tapering down to a small stalk with a blunt base; surface of cap soon practically glabrous on exposed places, but inherently fibrous and at first finely tomentose with rather loosely set slender hairs, irregularly ridged and pitted or nearly smooth, white, becoming creamy or buffy when rubbed, not viscid, margin lobed, thin, sterile. Flesh about 1 mm. thick, white, fleshy, soft, tender and moderately brittle, but distinctly fibrous; taste sweetish-woody, odor faint. The threads of the flesh are prevailingly parallel, rather loosely packed, about 3.5–5.2μ thick, sparingly branched and with numerous clamp connections. Mycelium white, rather stringy, conspicuous, running extensively among the rotting needles.

Hymenium peculiar, originating as irregular, rarely anastomosing ridges and teeth, the ridges growing quite irregularly in height also, and soon forming small, interrupted plates and flattened teeth of different lengths, like a miniature *Irpex*, the longest about 1 mm. long, densely fimbriated at their ends by slender hyphae of irregular length

which give a frosted appearance under low power. The hymenium, which is of a peculiar subwaxy character, is not very decurrent, leaving about 5–7 mm. of stem smooth.

Spores (of No. 3751) minute, smooth, white, 1.8–2 x 3.8–5μ, with an eccentric mucro, and an oil drop. Basidia about 4μ thick, 6-spored.

The entire plant is white, fading on drying to a creamy buff or yellow and becoming ridged and brittle. Most of our plants are far more delicate than would appear from most illustrations. Saccardo gives the size as up to 20 mm. broad, but Sowerby's plate 112 shows plants up to 34 mm. broad. Boudier's plate is best.

We have examined European plants from the Bresadola Herbarium and find them like ours. The basidia are about 5 x 17μ, 6-spored, confirming Patouillard's statement and agreeing with American collections; spores about 2 x 4μ.

Illustrations: Boudier. Icon. Myc. **1**: pl. 169.
Bulliard. Champ. Fr., pl. 453, fig. 1 (as *Hydnum sublamellosum*).
Greville. Scot. Crypt. Flora **5**: pl. 248.
Massee. Brit. Fungus Flora **1**: p. 149, figs. 4 and 5.
Patouillard. Hymen. Europe, pl. 3, fig. 19.
Smith. Brit. Basid., p. 385, fig. 87.
Sowerby. Engl. Fungi **1**: pl. 112 (as *Hydnum sublamellosum*).

3751. In pine needles, Tenney's Ravine, Nov. 14, 1919.
3787. Rotting pine straw, Nov. 20, 1919.

New Hampshire. Chocorua. Farlow, coll. Reliquiae Farlowianae, No. 362.
Reported from North Carolina (Schweinitz), Alabama (Earle, Banker), New York (Peck) and Vermont (Burt).

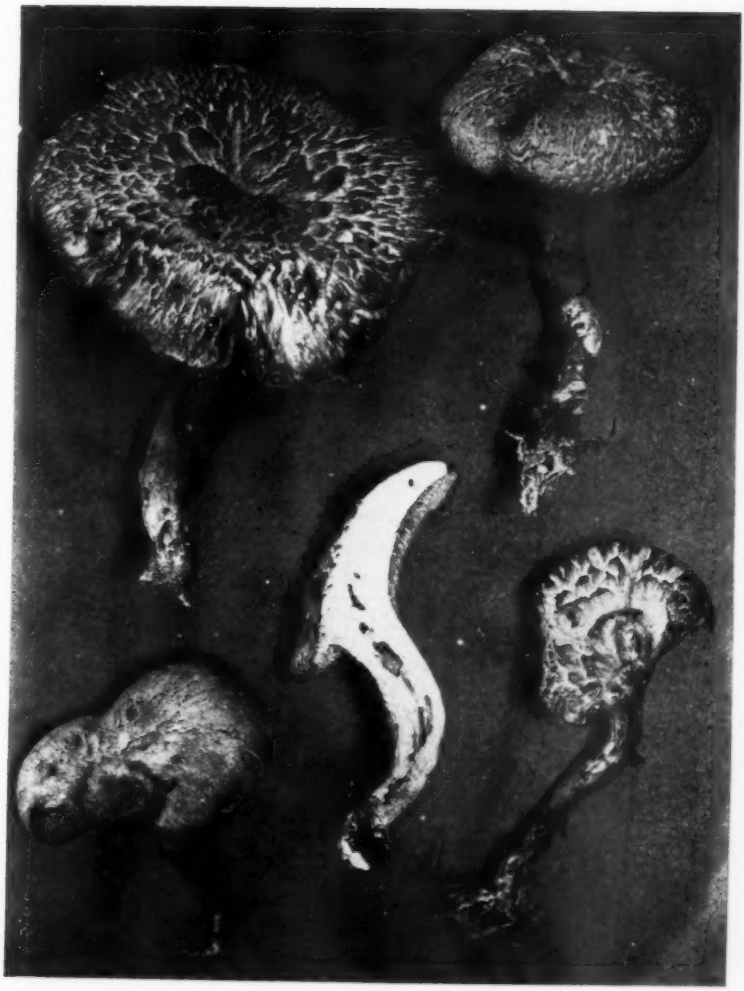
UNIVERSITY OF NORTH CAROLINA,
CHAPEL HILL, N. C.

EXPLANATION OF PLATES

PLATE 64

Fig. 1. Hydnum fennicum. No. 3414.
Fig. 2. Sarcodon Murrillii. Type.
Fig. 3. Hydnum cristatum. North Carolina (Asheville ?).
Fig. 4. Hydnum Underwoodii. No. 3446.
Figs. 5 and 6. Hydnum amarescens. No. 4373.
Fig. 7. Sarcodon roseolus. Type.
Fig. 8. Hydnum fumosum. Type.
Fig. 9. Hydnum fuligineo-album. No. 3761.
Fig. 10. Hydnum fuligineo-album from Bresadola Herb. (Italy ?).

PLATE 51



HYDNUM FENNICUM. No. 3414. Slightly reduced

PLATE 52

HYDNUM CRISTATUM. No. 5735

PLATE 53

HYDNUM AMARESCENS. No. 4373. Slightly reduced

PLATE 54

HYDNUM FULIGINEO-ALBUM. No. 3761

PLATE 55

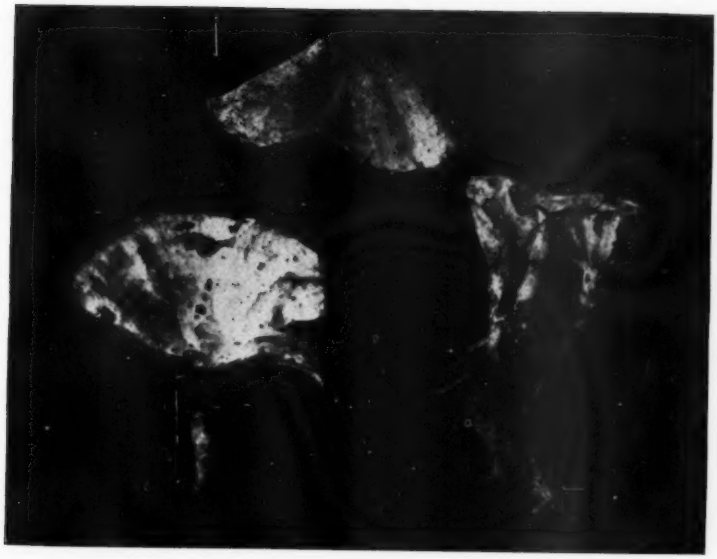
HYDNUM ALBIDUM. No. 5603

PLATE 56

HYDNODON THELEPHORUM

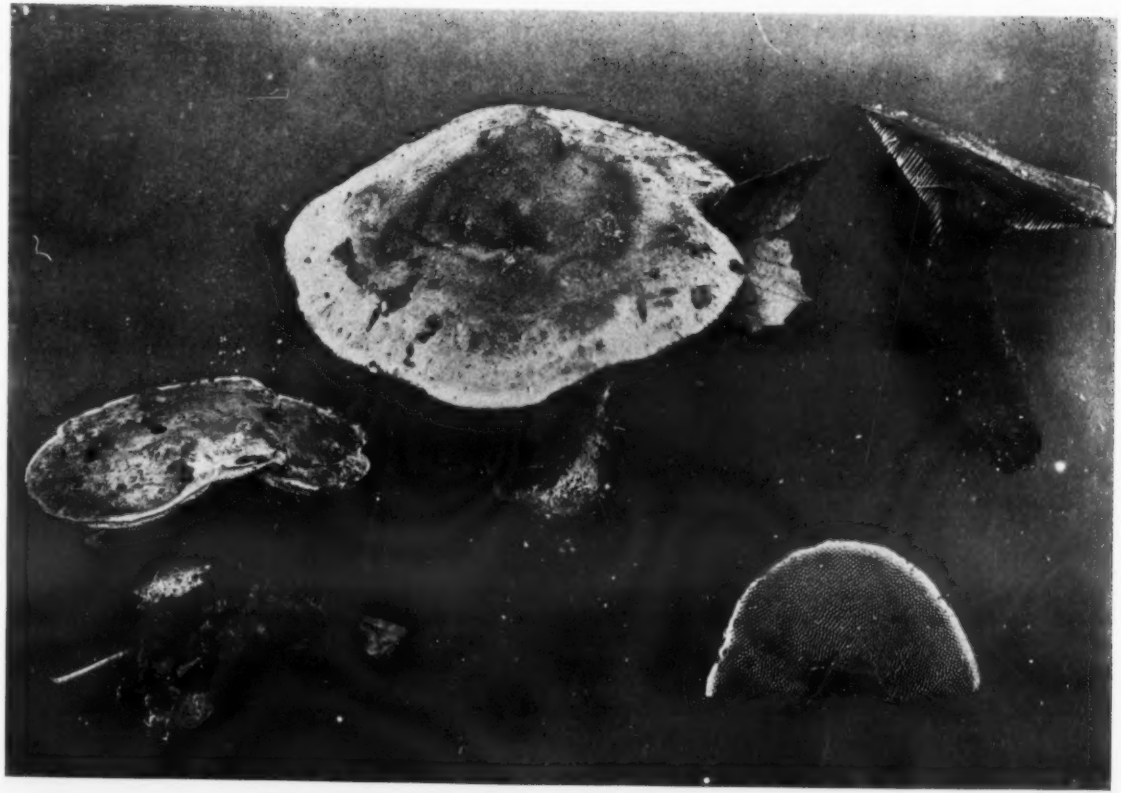
(Upper left) No. 7472; (upper right) Morce's Gap, Jamaica, No. 691; (center) Jamaica, No. 54; (lower row) Bahamas, No. 4833

PLATE 57



PHELLODON GRAVEOLENS. No. 4375

PLATE 58



HYDNELLUM SANGUINARIUM. NO. 3452. FORM WITH RED JUICE

PLATE 59

HYDNELLUM SANGUINARIUM. NO. 3426. FORM WITHOUT RED JUICE
Slightly reduced

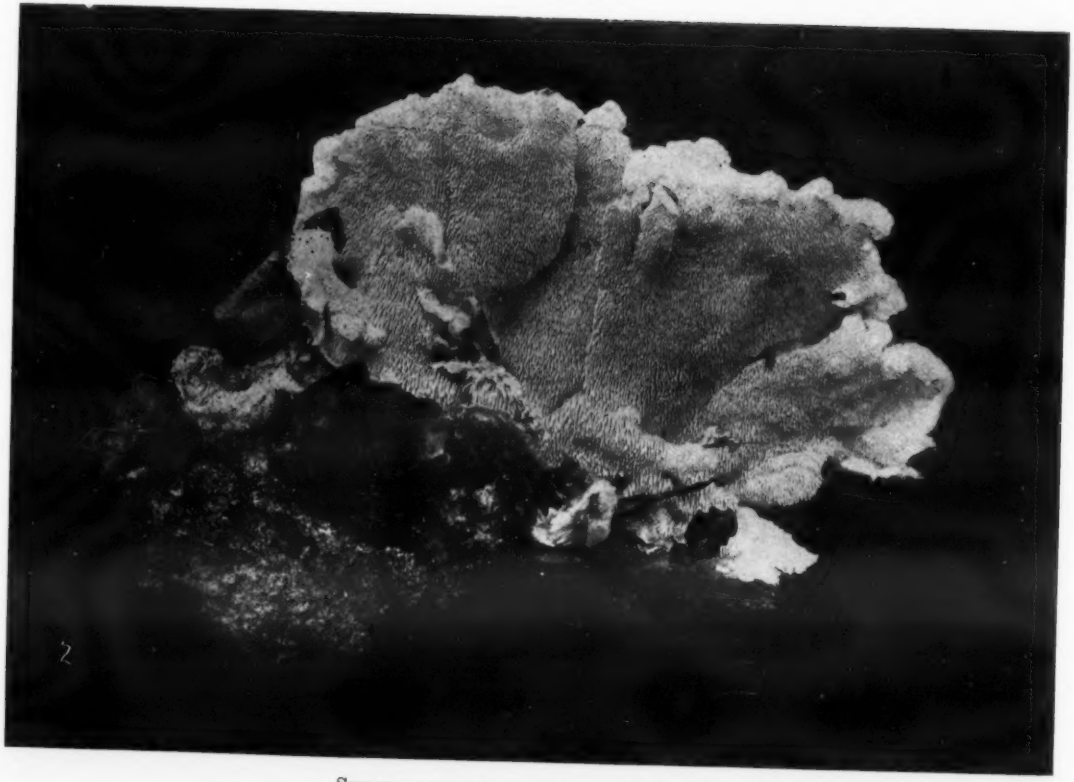
PLATE 60

HYDNELLUM SANGUINARIUM. No. 3426. FORM WITHOUT RED JUICE

PLATE 61

STECCHERINUM PULCHERRIMUM. No. 3456

PLATE 62



STECCHERINUM PULCHERRIMUM. No. 3456

PLATE 63

SISTOTREMA CONFLUENS. No. 3751

PLATE 64

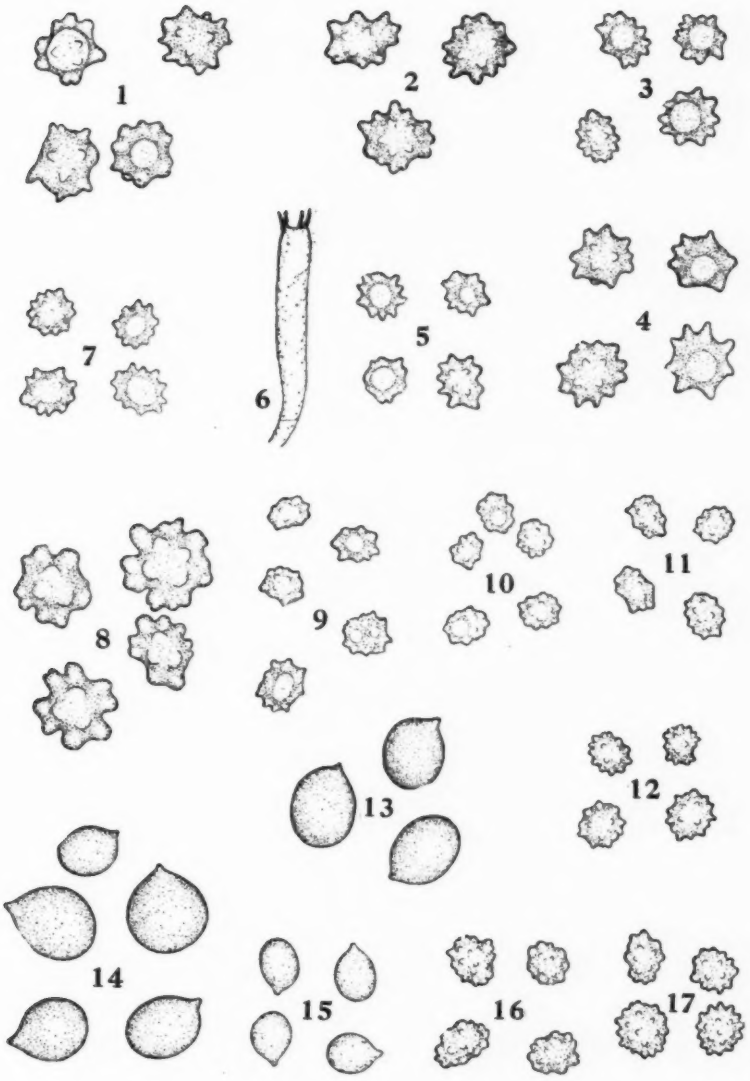
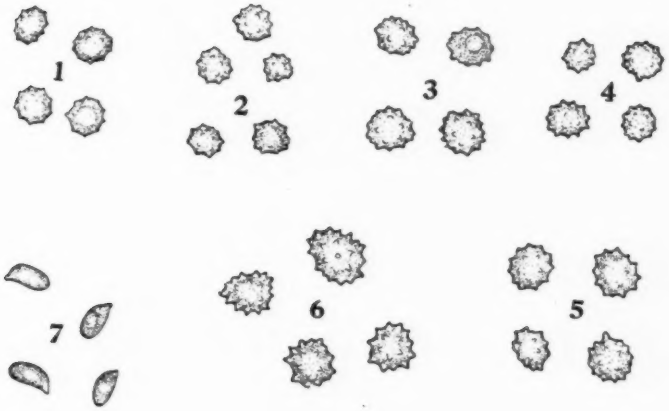
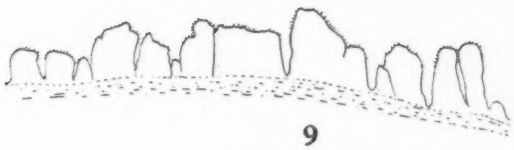
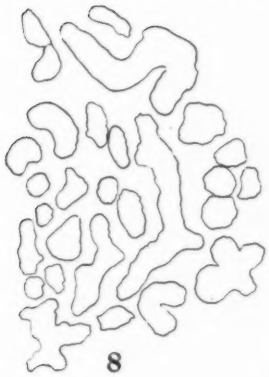


PLATE 65







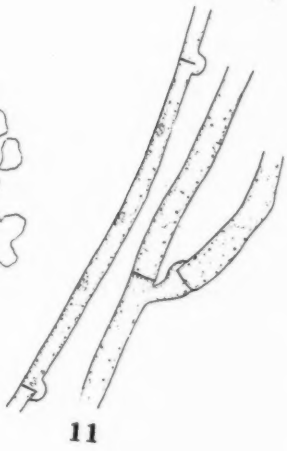


Fig. 11. Sarcodon reticulatus. Type.
Fig. 12. Phellodon carnosus. Vermont (N. Y. B. G. Herb.).
Fig. 13. Hydnum albidum. No. 5603.
Fig. 14. Hydnum albidum. Type.
Fig. 15. Hydnum species? Port Jefferson, L. I. (N. Y. B. G. Herb., as *H. albidum;* Peck and Earle, No. 817).
Fig. 16. Hydnodon thelephorum. No. 7472.
Fig. 17. Hydnodon thelephorum. Bahamas (Brace, No. 4833).
Fig. 6 × 810; all others × 1620.

PLATE 65

Fig. 1. Phellodon Ellisianus. No. 1325.
Fig. 2. Phellodon graveolens. No. 4625.
Fig. 3. Phellodon alboniger. No. 3411.
Fig. 4. Phellodon vellereus. Bolton, N. Y.
Fig. 5. Phellodon putidus. No. 1368.
Fig. 6. Phellodon Cokeri. No. 47a.
Fig. 7. Sistotrema confluens. No. 3751.
Fig. 8–11. Sistotrema confluens. No. 3787. Hymenium shown in surface and side view, hairs from upper third of teeth and hyphae of flesh.
Figs. 1–7 × 1620; figs. 8, 9 × 22; figs. 10, 11 × 810.

TUCKAHOE ON MAIZE

By Frederick A. Wolf

Plates 66 and 67

In the spring of 1925 the writer received from O. H. Phillips, Albemarle, N. C., a collection containing eleven tuckahoes, eight of which were on the stalks of maize, *Zea mays* L., and the others on pine roots, *Pinus* sps. The letter of inquiry in regard to the nature of these structures, which accompanied this packet stated that they were found in a field which was then planted in clover but which had grown a crop of corn during the previous year.

All tuckahoes which had previously come to hand in North Carolina, as reported by the writer in a recent paper (Jour. E. M. Sci. Soc. **38:** 127. 1922) were associated with the roots of pines, and were caused by the fungus, *Poria cocos* (Schw.) Wolf. Elliott, however, (Mycologia **14:** 222. 1922) was of the opinion that those which served as the basis of his studies in Arkansas were attached to the roots of sumac. Weber (Phytopathology (Abstract) **14:** 35. 1924) noted the occurrence of tuckahoe on citrus roots in Florida. He furthermore succeeded in developing the fruiting stage which he identified as *Poria cocos*.

The presence of tuckahoes on corn, a substratum on which they have not previously been found is a matter of especial interest, as is their possible identity with such structures on pine, sumac and citrus. It is then the purpose of this report to assemble the information at hand as a further contribution to our knowledge of this unusually interesting form.

The sclerotia on corn stalks in this collection represent several stages in the transformation of the host tissue from apparently normal stalks to well developed tuckahoes and show plainly that these tuckahoes are modified corn stalks. They are elongated structures each of which involves from one to three joints and they vary in diameter from slight enlargements of the stalk to masses 4 inches in diameter. The largest specimen taken weighed nearly $4\frac{1}{2}$ pounds.

The exterior is furrowed and fissured with longitudinal grooves. In the case of small specimens the cortex consists in large proportion of

the rind of the stalk whereas in large ones patches of the hard shiny cortical portions of the stalk remain, but it consists in large proportion of sclerotial cortex. The color of these tuckahoes simulates that of old corn stalks. They are hard when fresh but can easily be cut with a knife and become very hard and corneous on drying. The interior is whitish to slightly pink when fresh and has a decided mushroom odor, but on drying becomes grayish and is quite odorless.

On microscopic examination the host tissues are seen to be in various stages of disintegration. The pith and other parenchymatous portions are the first to be replaced by the fungous tissue. The sclerenchyma, collenchyma and xylem portions of the vascular bundles are more resistant and, though modified, persist to the extent of being recognizable. In these tissues the intercellular and intracellular spaces are seen to be completely filled with compact mycelium. The growth and massing of the mycelium within the stalk results in the gradual bulging outward of the rind which as the tension increases causes it to rupture, thus making longitudinal grooves. There is at the same time a stretching of the rind in a longitudinal direction which results in its breaking as indicated by isolated patches of rind at the exterior. Some tuckahoes are formed unilaterally and the host tissues can be plainly traced at one side through their entire length. In large sclerotia the substance of the stalk appears to be entirely appropriated except for the patches of rind which persist at the exterior.

In the light of previous experience in the production of fruit bodies all of the sclerotia were placed in water to soak and then were put into moist chambers in the laboratory. Within a week four of those on corn and two on pine had formed at the surface one or more white compact, fungoid crusts. Within an additional two weeks period the hymenial layers with large angular pores had matured. The hymenophores were pure white at first but with age became tinged with brown. The fruit-bodies from sclerotia on corn stalks and on pine roots were indistinguishable in gross appearance, accorded in size of basidia and basidiospores, and agreed with the measurements previously given (3).

Artificial cultures were prepared by transfer of bits of tissue from the interior of sclerotia from both pine roots and corn stalks to potato plugs. These, when kept in diffuse light in the laboratory, formed poroid crustose sporophores, whereas in other cultures which were prepared in the same manner and were kept in a photographic dark-room, no evidence of sporophore formation was noted and the resultant mycelium was loose and cottony. These cultures from tuckahoes on pine and on

corn were similar in appearance in every way and the basidiospores accorded in size and shape with those formed in nature.

The results of the foregoing observations and cultural studies, it must be admitted, are entirely contrary to what was anticipated. The similarity in morphology and cultural characters of the organism on corn and on pine manifestly can only be interpreted as showing that the two are identical. As stated in the previous account (3) there are a number of facts which strongly indicate, although they cannot be regarded as proof, that the sclerotia on pine roots are the result of parasitism. On the other hand all of the evidence on the mode of development of corn tuckahoes indicates that the fungus is a pure saprophyte. Such a condition would naturally lead one to suspect that two distinct species of fungi are involved. However such a conclusion does not necessarily follow, since, among wood destroying fungi, as is well known, there are a considerable number of species which attack living trees which also cause the decay of dead wood. When someone is so fortunate as to produce tuckahoes as the result of inoculation or in pure culture, an accomplishment which the writer has unsuccessfully attempted, then the identity of the fungus on corn, on pine, on sumac and on citrus can be established beyond doubt. At present it can only be stated that the evidence in hand indicates that they are specifically identical.

It may be of interest to mycologists to state at this point that corn tuckahoes have been deposited in the herbaria at the New York Botanical Gardens, New York, N. Y., at the Office of Pathological Collections, United States Department of Agriculture, Washington, D. C., at the University of Wisconsin, Madison, Wis., and at Cornell University, Ithaca, New York.

SUMMARY

Massive sclerotia commonly called tuckahoes have been found to occur on corn stalks. They had previously been noted in North Carolina on pines, in Florida on citrus and in Arkansas on sumac.

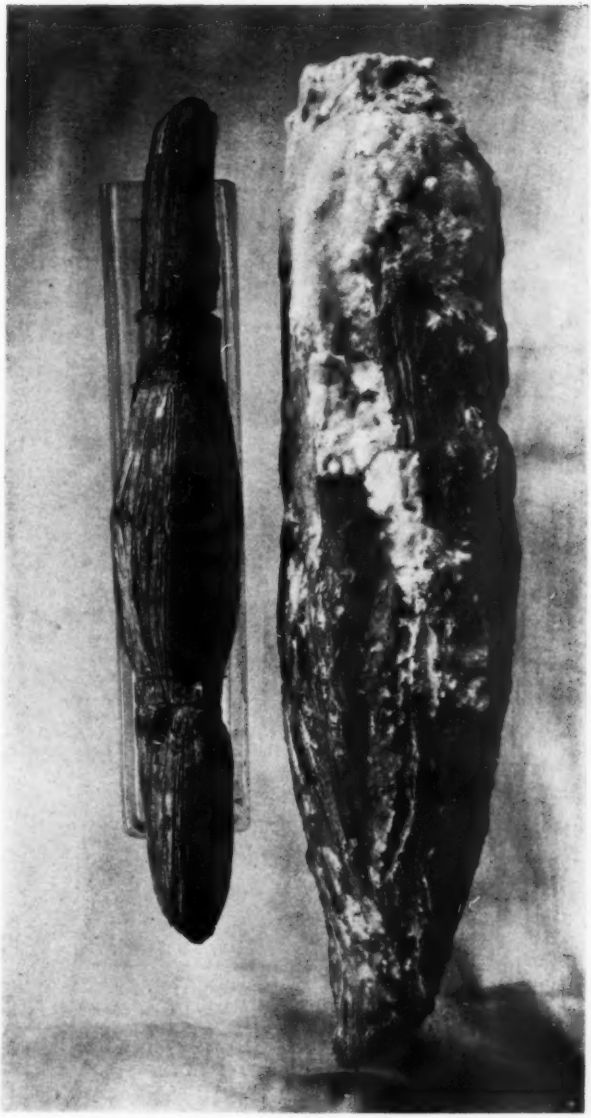
Fruit bodies of the *Poria* type have been developed on each of four tuckahoes from corn and two from pine.

Artificial cultures made from plantings of sclerotial tissues have given rise to sporophores.

The similarity of fruit bodies on tuckahoes from corn stalks and those from pine roots, and the identity of artificial cultures lead to the conclusion that the fungus, which causes tuckahoe formation on corn and pine and which in a previous account was given the name *Poria cocos.* is identical.

ORLANDO, FLA.

PLATE 66



TUCKAHOES ON CORN

The small one at the left shows only a small amount of modification of the corn stalk. Two of the cross marks on it are nodes, the other two fractures. The large one has a node near the center and produced several fruit bodies.

PLATE 67

PORIA STAGE, NEARLY NATURAL SIZE, OF TUCKAHOE ON CORN

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1925–1926

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CONTENTS

Constitution of the North Carolina Academy of Science..... 1
Proceedings of the Twenty-fourth Annual Meeting of the North Carolina Academy of Science..... 7
Proceedings of the Elisha Mitchell Scientific Society, October 14, 1924, to May 14, 1925..... 37
The Life and Habits of the Honey Bee. *H. B. Arbuckle*..... 47
Variation of Protein Content of Corn. *H. B. Arbuckle* and *O. J. Thies, Jr*..... 64
The New World of the Atom and Albert Einstein. *Archibald Henderson*..... 70
Some Undescribed Fungi on Sourwood, Oxydendron Arboreum (L.) DC. *Frederick A. Wolf*..... 94
The Seasonal Catch of Snakes at Raleigh, N. C. *C. S. Brimley*.... 100
Meteorological Inquiries from the Viewpoint of 1795. *Lee A. Denson*. 104
An Oil-bearing Shale of North Carolina. *Frank C. Vilbrandt*..... 108
Recent Developments in the Chemical Industries of North Carolina. *Frank C. Vilbrandt*..... 115
Investigation on the Germination and Heating of Cotton Seed in Warehouse Storage. *E. E. Randolph*..... 124
Progress on State Insect Survey with Comparative Data on Other Animal Groups. *Franklin Sherman*..... 129
Iron Coloration in Rocks and Minerals. *Gerald R. MacCarthy*..... 135
Two Rare Types of Abnormality in Cotton Seeds. *S. G. Lehman*..... 138
A New Dioecious Species of Choanephora. *J. N. Couch*..... 141
A Study of the Watermolds and Pythiums Occurring in the Soils of Chapel Hill. *James Vernon Harvey*..... 151
Notes on the Spiders of the Southeastern United States with Descriptions of New Species. *Sherman C. Bishop* and *C. R. Crosby*.... 165
Notes on the Genus Aphanomyces, with a Description of a New Semiparasitic Species. *J. N. Couch*..... 213
Plankton Collections in Lake James, North Carolina—Copepods and Cladocera. *R. E. Coker*..... 228
The Modern Electrometer. *Otto Stuhlman, Jr*..... 259
Notes on Woody Plants. *W. W. Ashe*..... 267
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